Individual Expertise and Team Performance: Results of Three Empirical Studies

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Judith Volmer
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1. Referentin oder Referent: Prof. Dr. Sabine Sonnentag

2. Referentin oder Referent: Prof. Dr. Werner Deutsch

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Abstract

The question of how high individual performance and team performance are linked to each other is important to determine what makes teams effective. This dissertation focuses on the impact of the performance level of the *best* team member on team performance beyond the average performance level of the team. The best team member is referred to as an expert showing superior competence with respect to various performance aspects (Ericsson & Smith, 1991). The core question to be answered is: What is the relationship between individual expertise and team performance? This dissertation comprises three studies that aimed at improving our knowledge about the causal relationship between individual expertise and team performance and the psychological processes underlying this presumed effect.

Study 1 examined how the score of the best team member, i.e., the expert is related to team performance. It further explored which processes mediate the impact of the best team member on team performance. Building on the input-process-output model of team performance (Hackman & Morris, 1975; McGrath, 1984) and on action theory (Frese & Zapf, 1994; Hacker, 1998), it was proposed that planning behavior is a mediator of expertise level and team performance. Planning behavior was differentiated into local planning (i.e., thinking about and communicating the next step without extensively reflecting on it) and planning ahead (i.e., reflecting and deciding about the future course of action). In a quasi-experimental study with 106 computer science students, the individual and dyadic problem solving processes while working on two complex software design tasks were observed. Results indicated that the score of the best team member had a positive impact on team performance in contrast to the score of the average team member. Mediation analyses revealed that local planning partially mediated the relationship between high individual performance and team performance.

Study 2 also investigated how individual performance relates to team performance. However, in this study two different types of expertise were explicitly distinguished. The first type of expertise was actual expertise (i.e., knowledge about the task's facts and procedures) and the second type of expertise was perceived expertise (i.e., being perceived by others as excellent). In an experimental study with 200 students from non-technical majors, the distinct and combined effects of actual and perceived individual expertise on dyads' team performance were tested. As predicted, actual expertise had a positive impact on team performance. Contrary to expectations, perceived expertise had no impact on team performance, and there was no interaction effect of actual and perceived expertise.

Study 3 tested the impact of individual expertise on team performance in a longitudinal field study. More specifically, it was investigated how the performance of the best team member in different functions of a team (i.e., task functions and team functions) was related to team performance. Task functions refer to behavior that aid the completion of task-related activities, whereas team functions facilitate the interpersonal interaction necessary to work as a member of the team (e.g., Bales, 1950; Marks & Panzer, 2004). Participants were 96 software professionals from 20 teams. The basic argument was that the performance level of the best team member in task functions positively predicts change in team performance. Furthermore, team members high in team functions were expected to contribute to team performance beyond the best member in task functions. Results based on multi-source data revealed a positive impact of task functions at Time 1 on team performance at Time 2. Moreover, there was evidence that the scores of the best team members in team functions accounted for additional variance in team performance.

This research provides consistent evidence from the laboratory and field setting for the crucial role of the performance level of the *best* team member beyond the average performance level of the team. One should especially consider team members with exceptional competencies when selecting team members and staffing teams. In training situations, task functions as well as team functions should receive attention. Future research should examine how individual expertise develops in teams and how knowledge from the best team member is distributed within the team.

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Chapter 1: General Introduction

One of the most important organizational changes over the past 20 years is the increased implementation of teamwork (Guzzo & Dickson, 1996; Ilgen, Hollenbeck, Johnson, & Jundt, 2005; Kozlowski & Bell, 2003; Poole, Hollingshead, McGrath, Moreland, & Rohrbaugh, 2004). Teams are described as complex, adaptive, and dynamic systems (Ilgen et al., 2005; McGrath, 2000) that consist of two or more people who work interdependently towards a common goal (Salas, Dickinson, Converse, & Tannenbaum, 1992). Today's workforce has to react to the complex demands and constantly changing work requirements (Ilgen & Pulakos, 1999; Sonnentag & Frese, 2002). Complex tasks require tight interdependent working that can only be accomplished by teams (West, 2002). As teams are composed of individual team members, individual performance and team performance are closely linked to each other.

For teams to work effectively, it is necessary to coordinate their individual resources and to use these resources wisely (Steiner, 1972). One of the greatest resources a team has is the expertise of its members (McGrath, 1984). Expertise refers to individuals who show superior and exceptional competence (Ericsson & Smith, 1991).

Yet, what makes teams effective? The answer to this research question seems to be simple, and one might suggest putting as many competent individuals as possible in a team to achieve high team performance. However, the relationship between multiple levels of phenomena, in this case high individual performance (i.e., expertise) and team performance, has been shown to be much more complex and still needs further investigation (Klein & Kozlowski, 2000; Rousseau, 1985). Selecting individuals for high performance at the individual level does not guarantee that these individuals will show high performance at the collective unit (Stewart, 2003). Research has been concerned with the generic question of what makes teams effective (Ilgen et al., 2005) and has emphasized that knowledge about team composition might be useful to determine what makes teams work successfully.

This dissertation was conducted in the project "Expertise and task-related communication" which was supported by a grant from the German Research Foundation (DFG; SO 295/3-1, 3-2) that is greatly appreciated.

However, researchers' understanding of the effects of team composition on team processes and team outcomes largely remains a black box (Ilgen, 1999; Porter, 2005). The focus on team composition with a special interest in the best team member's performance beyond the aggregated level of team performance addresses research that can be applied by those responsible for managing, and in particular, staffing teams (e.g., Klimoski & Jones, 1995; Morgeson, Reider, & Campion, 2005). Having a better understanding of composition effect could make it easier to create a functioning team.

Thus, the goal of this dissertation is to increase our knowledge concerning the questions (1) *if* individual expertise is related to team performance and (2) *how* individual expertise and team performance are related to each other.

The Expertise Concept

Expertise research is concerned with the description and explanation of performance differences between individuals in a specific domain. Traditionally, research on expertise was originated in cognitive psychology building on research on world-class chess players (de Groot, 1965; Simon & Chase, 1973). Only in the last 15 to 20 years has the topic of expertise been shifted to work settings (Hacker & Vaic, 1973; Hacker, Wetzstein, & Römer, 2002; Sonnentag, 2000). The domains of expertise in expertise research vary broadly and include fields such as chess, music, medicine, software engineering, and the arts and science (Ericsson, Charness, Feltovich, & Hoffman, in press).

The core defining characteristic of expertise is high and superior performance (Ericsson, 2005; Ericsson & Charness, 1994; Ericsson & Smith, 1991; Sonnentag, 1998). Furthermore, Ericsson and Smith (1991) point out that one needs to examine and identify repeatedly superior performance on representative tasks. This implies that achievements which occur only once in a lifetime are excluded (e.g., a single scientific discovery, a historically significant decision, or a single victory in a sport). In these cases expertise can not solely be attributed to the person's characteristics. Taken together, expertise can be defined as "consistently superior performance on a specified set of representative tasks for a domain" (Ericsson & Lehmann, 1996, p. 277).

There are two major concepts of expertise that differ from each other with respect to the criterion of expertise (Sonnentag, 2000). The *experience approach* builds the criterion of expertise on length of experience (e.g., Chi, Glaser, & Rees, 1982;

Wiedenbeck, Fix, & Scholz, 1993) and thereby contrasts experts with novices, i.e., persons with a limited amount of experience in a certain domain. In contrast, the *excellence approach* emphasizes the high performance aspect rather than the amount of experience. Experience might be necessary to show high performance, but more importantly one has to show outstanding performance and to possess superior knowledge in a certain domain (Ericsson, 2005; Hacker, 1992; Sonnentag, 1998). Thus, studies conducted in the excellence approach focus on individuals with superior performance rather than on length of experience. In this dissertation the excellence approach is adopted.

Most studies on expertise have described expertise with respect to individual task accomplishment (Ericsson, 2005; Sonnentag, 2000). However, due to the increasing prevalence of teams in organizations (Devine, 2002; West, Borrill, & Unsworth, 1998) research on the impact of experts on team performance is necessary to provide valuable recommendations for personnel selection and team composition.

Teamwork

The term "team" has largely replaced the term "group" in the field of organizational psychology and often both labels are used interchangeably (Guzzo & Dickson, 1996). In this dissertation, the term team will be used for describing social entities of two or more people working cooperatively on a task.

Hackman and Morris (1975) addressed the question of how teams can work effectively. They propose a classic systems model and theoretical framework (Hackman & Morris, 1975; McGrath, 1964, 1984; Steiner, 1972) that pictures teamwork in terms of input that leads to processes that in turn lead to outcomes (the input-process-output-model, or I-P-O-model; for a discussion and further refinement of this model see Ilgen et al., 2005). Input factors can be for example the pattern of member skills, attitudes, and team member personality characteristics. Team interaction processes can be described as for example the coordination of individual contributions and communication processes. Output factors are conceptualized in a two-fold way: On the one hand these are performance outcomes such as performance quality, speed to solution, and number of errors and on the other hand these are other outcomes such as member satisfaction, cohesiveness, attitude change, and sociometric structure (Hackman & Morris, 1975; McGrath, 1964, 1984).

In this dissertation individual expertise is considered as input, planning behavior as process, and team performance as output.

Team Member Input

Often, researchers aggregate attributes of individuals to the team-level (Barrick, Stewart, Neubert, & Mount, 1998; Barry & Stewart, 1997; LePine, 2003; LePine, Hollenbeck, Ilgen, & Hedlund, 1997). The basic line of argument is that teams consist of members with a certain set or combination of attributes, and aggregation is simply necessary to account for those attributes (LePine et al., 1997). Barrick et al. (1998), for example, found positive relationships between aggregated ability and personality measures and team outcomes. Similarly, LePine (2003) examined the relationship between aggregated individual-level member cognitive ability, member achievement, member dependability, and member openness to experience and provided evidence for a relationship between aggregated measures and post change decision-making performance.

Notwithstanding the usefulness of aggregating team member input which has been proven to be theoretically and empirically useful (cf., for example Halfhill, Sundstrom, Lahner, Calderone, & Nielsen, 2005; Stewart, 2006), there is also evidence for the crucial role of the best team member in team settings (Baumann & Bonner, 2004; Bonner, Baumann, & Dalal, 2002; Henry, 1995). Research has shown that the best team member exerts far more influence in teams compared to other team members. Henry (1995) found in a judgment task that instructing team members to share information or to try to identify their best team member significantly improved team performance. Bonner et al. (2002) examined in a laboratory study the effects of performance feedback on subsequent decision making and performance in three-person groups and found that groups gave more weight to the input of their highest performing team member. In fact, they gave twice as much weight to the highest performing team member relative to other team members when expertise rankings based on prior performance were made available. In a follow-up study with a more complex task and a-priori assumptions about the best team member’s influence, Bonner (2004) could show that teams are generally fairly good at calibrating their team members’ expertise. The best team member had twice as much influence and teams performed at the level of the best of equivalent individuals.

Considering the operationalization of team member input, it seems fruitful to consider the best team member score and to examine its influence beyond the average team performance. Focusing on the best team member and accounting for the average performance level in the team is a rather new approach and contributes to existing research on team composition by providing a more detailed approach that might contribute to an understanding of what makes teams effective.

Team Processes

Working in teams increases the interdependency among employees, producing a larger demand for coordination (Campion, Medsker, & Higgs, 1993). For teams it is crucial to coordinate the actions of individual team members, and to open channels for members to share information (Weingart & Weldon, 1991). Planning refers to a regulatory mechanism by which teams decide on a principal course of action for goal accomplishment (Argote & McGrath, 1993; Hackman, 1987, 1990; Marks, Zaccaro, & Mathieu, 2000; McGrath, 1984; Stout, Cannon-Bowers, Salas, & Milnovich, 1999). The extent to which teams show planning behavior should mediate the relationship between individual expertise and team performance. Therefore, planning behavior is considered as a mediator.

Team Outcomes

Team outcomes are mostly defined broadly (e.g., Hackman, 1987, Sundstrom, 1990). For example, Guzzo and Dickson (1996, p. 309) describe three categories of team performance: (a) outcomes produced by the team (e.g., quality and quantity of products, production speed, customer satisfaction), and (b) consequences a team has for its members, and (c) the enhancement of a team's capability to perform effectively in the future. In this dissertation, the criterion (a) is considered with an emphasis on quantity and quality of the team's solution or product.

Outline of this dissertation

Results from team literature provide some useful information about the relationship between individual performance and team performance. However, several questions remain open. For example, if one can show that individual expertise is positively associated with team performance, what mediates this relationship? Are there different kinds of expertise and how are they related to team performance? Are the processes observed in the laboratory identical to those in the field setting? Do different team members possess different team functions and how do these functions combine into team performance? Is individual expertise a useful input factor which adds to the existing team composition literature? These and other issues are addressed in the following chapters of this dissertation and the findings may advance our understanding of the relationship between individual expertise and team performance and the underlying mechanisms.

More specifically, Study 1 (Chapter 2) tests with a quasi-experimental design the question of *if* individual expertise is related to team performance. Furthermore, this study addresses the question of *how* individual expertise is related to team performance and focuses on planning behavior as a possible mediator. Planning behavior is differentiated into local planning (i.e., thinking about and communicating the next action steps without extensively reflecting on it) and planning ahead (i.e., reflecting and deciding about the future course of action). Computer science students work individually and cooperatively on complex software design tasks and their interaction process is videotaped. The conjoint task solution serves as measure of team performance.

Study 2 (Chapter 3) disentangles the effects of different types of expertise on team performance, that is actual expertise and perceived expertise. In an experiment, we tested if someone has to possess actual expertise (i.e., knowledge about the task's facts and procedures), perceived expertise (i.e., being perceived by others as excellent performer), or a combination of both types of expertise to attain high team performance. In an experimental study, students from non-technical majors work in dyads on a web-design task which provides a measure of team performance.

Study 3 (Chapter 4) examines the impact of individual expertise on team performance in a longitudinal and multi-source field study. It is tested how the performance of the best team member in different functions of a team (i.e., task functions and team functions) is related to team performance. Task functions refer to the completion of task-related activities and team functions facilitate the interpersonal interaction between team members (Bales, 1950; Bales & Slater, 1955; Marks & Panzer, 2004). In real-work software design teams we investigated if the best team member in task functions predicts team performance beyond the average team score in task functions. Furthermore, we examined if the best team member in team functions can predict team performance beyond the score of the best team member in task functions. It is also of interest if the expected results from the laboratory studies (Study 1 and Study 2) can be replicated in a longitudinal field setting.

Finally, in Chapter 5 the main results of this dissertation are summarized and integrated, the strengths and limitations are considered, theoretical and practical implications are discussed and recommendations for future research are offered.

Chapter 2: High Individual Performance and Team Performance: The Mediating Role of Planning Behavior

Summary

The present study tested how high individual performance is related to team performance. Planning behavior was investigated as a mediator. Participants (N = 106) worked individually and cooperatively in dyads on three complex software design tasks. As predicted, high individual performance was positively related to team performance. Furthermore, results revealed that local planning (i.e., thinking about and communicating the next step without extensively reflecting on it) but not planning ahead (i.e., reflecting and deciding about the future course of action) partially mediated the relationship between high individual performance and team performance. These findings emphasize the relevance of high performers in teams and underline the potential of planning behavior as an important factor promoting team performance.

Introduction

Complex task environments require problem solving, use of knowledge, and continuous learning. Within the last decades, the way work is performed in organizations has partly shifted from individuals to teams (Gully, Incalcaterra, Joshi, & Beaubien, 2002; Ilgen et al., 2005; Poole et al., 2004; Schooler, 2002). Managers are often concerned with the question of how to staff their teams in order to achieve high team performance. In general, it is suggested that this can be assured by composing teams in a way that the necessary skills and knowledge are available (Hackman, 1987).

Despite extensive research within the group context (see Guzzo & Dickson, 1996; Ilgen et al., 2005; Levine & Moreland, 1990, for reviews) the question of how individual characteristics, team processes and team outcomes are inter-related has so far been largely neglected. Yet, within a team one or more individuals must perform specific team performance enhancing behaviors. Teams must rely on individuals who show high levels of performance. There is a lack of studies that investigate the mechanisms of how individuals who perform at a high level increase team performance, i.e. studies that clarify the question whether it is beneficial to have a highly performing individual in a team and if so, why it is beneficial. For example, in personnel selection, knowledge about one individual's contribution to team performance would be extremely useful as one could determine which specific behavior a candidate should possess when they are to work in a specific team. Furthermore, in training, knowledge about one individual's contribution to team performance would allow training specific behavior of employees that in turn enhance team performance.

Thus, the purpose of this article is to report a study intended to increase our understanding of the factors that link individual input factors (i.e., individual performance level) with team output factors (i.e., team performance). This study differs from most of the other studies in past team research by explicitly examining the relationship between the individuals' performance level and the team's performance level. Therefore, the present study extends previous research on teams by analyzing the relationship between individual and team level performance. Furthermore, as we were interested in the process that takes place between individual performance and team performance, we examined planning as a possible mediator between individual and team performance.

The conceptual framework for this study follows work from Hackman and Morris (1975) and McGrath (1984). These scholars expressed teamwork in terms of input that leads to processes that in turn lead to outcomes (the input-process-output, or I-P-O-model). This conceptual framework was often applied in earlier studies on team performance. For example, Barry and Stewart (1997) examined how personality measures (input factor) are correlated with open communication (process) and team performance (output factor). Drach-Zahavy and Somech (2001), also applying the I-P-O-model, investigated the influence of functional diversity (input factor) on information exchange (process) and team innovation (output factor) in a school setting (see Ilgen et al., 2005, for a review).

Furthermore, we are referring to action theory as a framework for analyzing the mediator in the relationship between high individual performance and team performance. Action theory offers a useful framework for analyzing individual and team actions and for explaining high performance (Frese & Zapf, 1994; Hacker, 1998; Tschan, 1995). Adopting this action theory perspective, we focus on planning as a crucial step in the action process.

Specifically, we differentiate between two different types of planning, namely planning ahead and local planning. The proposed mediation effects of planning ahead and local planning are depicted in Figure 1.

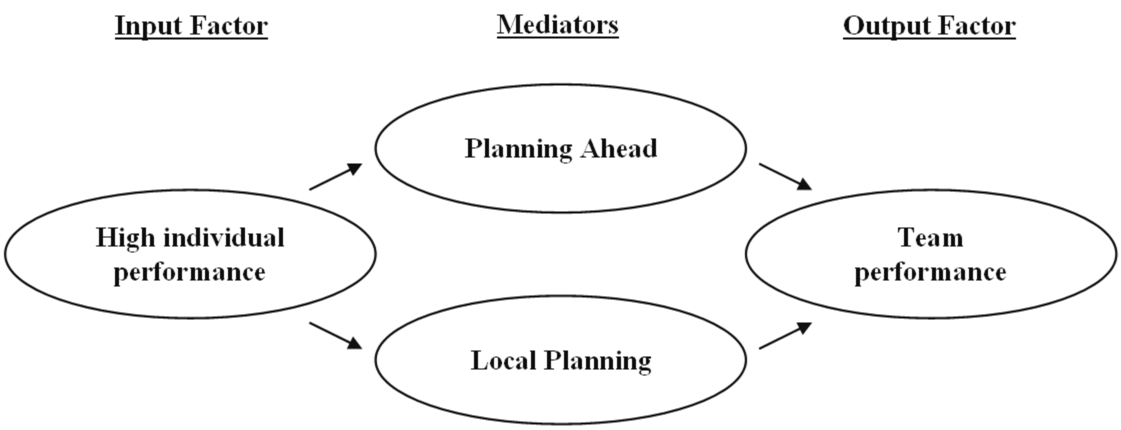

Figure 1. *Planning as mediator in the relationship between high individual performance and team performance (conceptual model).*

High Individual Performance

According to Ericsson and Smith (1991), high performers are persons with superior task performance. They differ from others in their performance level as well as their performance-related problem solving processes and knowledge (Sonnentag, 2000).

High Individual Performance and Team Performance

One of the most important resources a team has is the expertise of its team members (Hackman, 1987; McGrath, 1984). Hackman (1987) for example, concluded that “the most efficient way to make sure a team has the expertise it needs for its work is simply to assign talented individuals to it" (p. 326). It is one defining characteristic of high performers that they show superior performance and exceptional competence (Ericsson & Smith, 1991). This implies that they will show good performance on the tasks and sub-tasks assigned to the team. Therefore, we consider high performers as important contributors to high team performance. Empirical research provides support for this assumption. Bottger and Yetton (1987) have shown that increasing team members’ competencies increases team performance. Bonner et al. (2002) found that experts positively influenced team decision making and team performance. Baumann and Bonner (2004) demonstrated in an experimental study that reliance on the best member was positively related to team performance. High performers are expected to contribute more to team performance and to cause other team members to add more to team performance (Franz & Larson, 2002). High performers’ behavior in cooperative work settings implies that high performers act as a role model for the other team members. In sum, we assume that high individual performance will be positively related to team performance.

Hypothesis 1: High individual performance will be positively related to team performance.

Planning Behavior and Team Performance

Planning allows team members to coordinate the actions of individual team members and to open channels for members to share information (Weingart & Weldon, 1991). Planning refers to a regulatory mechanism by which teams decide on a principal course of action for goal accomplishment (Argote & McGrath, 1993; Hackman, 1987, 1990; Marks et al., 2000; McGrath, 1984; Stout et al., 1999). By planning, task activities are organized and the degree to which team members share an understanding of each other's needs and information requirement is increased (Stout et al., 1999). Plans serve to facilitate the performance of the task at hand (Gollwitzer, 1996). Planning is central to successful task performance in work teams because in teams where tasks have to be solved collectively there must be agreement on how task activities are organized over time. Knowing who is going to do what and when allows team members to coordinate their actions effectively and to avoid performance deficits due to coordination losses (Steiner, 1972).

We distinguish between two planning categories: *planning ahead* and *local planning*. The first category *planning ahead* implies that one reflects and decides about the future course of action and thinks about what to do next and what to postpone. The second category *local planning* means that one thinks about the next step and communicates the next step to the cooperation partner without extensively reflecting on it (Sonnentag, 1998). Examples of the category *planning ahead* are statements such as "We can improve it later, that's fine for now", "We shall make the final changes afterwards" or "We should discuss this topic later on". Examples of the category *local planning* are statements such as "I will start writing it down now", "Okay, let's make a table", or "Let's go into more detail now".

We assume that planning ahead is positively related to team performance as it reduces coordination problems. Tesluk and Mathieu (1999) investigated teams that faced obstacles to goal accomplishment. Teams that were most likely to overcome problems were those that anticipated problems in advance and had flexible plans in place from the very beginning. In a study of 48 self-managing project teams, Janicik and Bartel (2003) found that higher levels of initial temporal planning contributed to the formation of norms that emphasize the awareness of and attention to time resulting in better coordination and team performance. In sum, we expect planning of future action steps (i.e., planning ahead) to be positively related to team performance.

Hypothesis 2: Planning ahead will be positively related to team performance.

Similarly, we consider the extent to which the next action steps (i.e., local planning) are communicated to be related to team performance. By planning the next action steps, the work course is organized and the team members know exactly what each of them is going to do next. Team members have a shared knowledge about how they accomplish their work and can encounter upcoming problems immediately. This reduces coordination losses and insecurities about what to do next and will consequently save time and resources. In a simulation experiment, Stout et al. (1999) were able to show that increased planning of the completion of the very next action steps and coordination improved task accomplishment. In sum, we assume that a high amount of planning of the next action steps (i.e., local planning) will enhance team performance.

Hypothesis 3: Local planning will be positively related to team performance.

High Individual Performance and Planning Behavior

Research on expertise and high performance has shown that high performers show specific approaches to task accomplishment (for a review cf. Sonnentag, 2000). Compared to moderate performers, high performers set more specific and long-term goals and focus more on their work priorities (Tripoli, 1998; Vitalari & Dickson, 1983). In difficult and ill-structured situations they engage more in planning (Klemp & McClelland, 1986; Leithwood & Steinbach, 1995). Thus, high performers are characterized by very specific ways of accomplishing their tasks.

Planning the future course of action while working on a task requires having a cognitive representation of how one might attain the task goal. There is evidence that high performers are better able to anticipate possible drawbacks and that they possess a better representation of the task (Frese & Zapf, 1994). Therefore, high performers will be more able to make up a future action plan. In sum, we expect high individual performance to be positively related to planning ahead.

Hypothesis 4: High individual performance will be positively related to planning ahead.

Not only planning ahead has been shown to be related to individual performance. Sonnentag (1998) showed in a study with professional software designers at the individual level that highly performing software designers were more engaged in local planning behavior compared to moderate performers. Stout et al. (1999) describe planning as the process of orchestrating the sequence of interdependent actions that allows team members to align their individual contributions in order to attain the goal.

High performers will be better able to know what to do next. Therefore, we expect high individual performance to be positively related to local planning.

Hypothesis 5: High individual performance will be positively related to local planning.

As stated in Hypothesis 1, we expect high individual performance to be positively related to team performance. In addition, high performers have been shown to be characterized by a planning strategy which is focused on the anticipation of future states, in contrast to merely reacting to momentary states (e.g., Hacker, 1992). Therefore, we propose that the degree to which teams have developed a representation of the future action steps and the degree to which they anticipate future task difficulties (i.e., planning ahead) partially mediates the relationship between high individual performance and team performance. As there might be other motivational and cognitive processes that account for a relationship between high individual and team performance, we only suppose partial mediation, in contrast to full mediation. In sum, we propose the following hypothesis:

Hypothesis 6: The positive relationship between high individual performance and team performance will be partially mediated by planning ahead.

Similarly, we expect the relationship between high individual performance and team performance to be mediated by local planning. In order to achieve high team performance communication of the next action steps will be necessary. This ensures that all team members know better what to do next. In sum, we expect local planning to partially mediate the relationship between high individual performance and team performance.

Hypothesis 7: The positive relationship between high individual performance and team performance will be partially mediated by local planning.

Method

Overview

In this study we examined how individual performance and team performance are interrelated. In the first part of the study, participants worked individually on a first software design task, followed by a second software design task in which they worked alternatively individually and cooperatively in dyads on the task. Next, participants worked cooperatively in dyads on a third software design task. Concerning the type of task, the tasks were similar but each of them was different from one another with respect to the specific task requirements.

As the study was part of a larger research project, we did not analyze all three software design tasks for the present study, but considered only the first and the third task. Thereby, the first task provided a measure for individual performance and the third task provided a measure for team performance.

Participants

A total of 112 computer science students from a large German Technical University participated in this study. They were approached via mailing lists, newspaper advertisements, and flyers distributed on the university campus. Participation in the study was voluntarily. For participating, students received 30 Euros (approximately $US40). Payment was not contingent on task performance. Due to technical problems (microphone dysfunction and broken videotapes), data from four participants was lost. Additionally, data from one participant was eliminated because of an extreme outlier in previous work experience. Data from the remaining 106 participants are reported here. Participants ranged in age from 18 to 40 years, with a mean age of 24.4 years. The majority (84 percent) of all participants were male. On average, they were in their third year of study (SD = 3.0) and had 9.2 months (SD = 13.2) of professional experience in software design. This experience was obtained by working as an intern, as a working student or as a temporary employee in a professional software company. Forty dyads were composed only of men and 13 teams were mixed-gender. Data about previous acquaintance of team members as well as previous shared work-experience revealed that none of the participants had worked with each other before and that 75.5% of the participants had not seen each other before.

Material

As software design tasks, the Library Management Problem, the Lift Control Problem, and the Financial Management Problem were chosen (Détienne, 1995; Guindon, 1990; Hoc, 1983). The Library Management Problem requires developing an automatic documentation retrieval program for a library, the Lift Control Problem demands designing a software that controls the movement of N lifts with M floors, and the Financial Management Problem (slightly modified from Détienne, 1995) requests producing information about the amounts to charge the members of a sailing school, the club's annual turnover, and the sailing statistics.

More specifically, the Library Management task specifies which questions form the basis for obtaining books (i.e., "books associated to one keyword", and "books associated to two keywords"; Détienne, 1995, p.140) and the results that should be obtained (e.g., "a list of books, if this list is not empty"; Détienne, 1995, p.140). The Lift Control Problem asks participants to image that they have to install a system with N lifts in a building with M floors. The Financial Management Task provides participants with the diverse rates and information about the members and their sailings. The rates depend on the members' situations and on some characteristics of the sailings (e.g., "each sailing boat has its own rate per hour, and sailing costs are calculated by the hour."). For all three tasks a number of constraints must be taken into account. All three tasks can be characterized as ill-structured and knowledge-rich tasks specified by an informal, incomplete, and ambiguous description (Guindon, 1990). Thus, these tasks incorporate the basic features of realistic software design tasks.

Procedure

As data was gathered as part of a larger research project on software design, some of the participants underwent a communication manipulation. To ensure that this manipulation did not influence the test of our hypotheses, we ran analyses controlling for the manipulation. We found that this did not change the results of the present study.

Each participant took part in the overall study, lasting 4 hours (including four breaks with a total time of 17 minutes). In each trial, there were two participants and two experimenters. On entering the lab, the 2 participants were introduced to each other and then led into separate experimental rooms. Next, participants were informed about the nature of the study and the upcoming procedure. They were told that we were interested in gathering information about how people approach software design tasks. Additionally, participants were informed that tape and video recording will take place. Next, both participants filled out a questionnaire that assessed demographic information. Then, the first software design task, i.e., the Library Management Problem was assigned. Participants completed the task individually. Participants were told that they did not need to write a detailed program but should produce a design solution that one could hand to a professional programmer who would implement the program. No restrictions with respect to design method, programming language, and notations were made. Participants were given 30 minutes for task completion and were informed that this time frame is less than they would have in practice but that the experimental setting requires time restriction for this. During task completion, the method of thinking aloud was used. In accordance to Sonnentag (1998), the following verbalization instruction was used: “I am not only interested in the solution you arrive at, but also *how* you arrive there. I would like you to think aloud while working on the task. What does thinking aloud mean? Take it literally. Think in a loud voice. Please verbalize everything that is in your mind while your are busy with the task, even if it might seem unimportant, including thoughts and ideas that at first glance might have nothing to do with the task. It is important that you do not judge your thoughts before verbalizing them.” (Sonnentag, 1998, p.706). When participants stopped verbalizing for more than 15 seconds they were prompted to continue (“Please keep on talking.”). Verbalizations were tape-recorded and later transcribed fully. Additionally, participants were asked to write down their software design solution.

Next, participants worked in dyads. They worked cooperatively on the Lift Control Problem and on the Financial Management Problem. As we were not interested in the results of the Lift Control Problem in this study, we will only refer to the Financial Management Problem. Participants had 30 minutes to accomplish the Financial Management Problem. Again, participants were told that they did not need to write a detailed program but should produce a design solution that they could hand to a professional programmer who would implement the program. No restrictions with respect to design method, programming language, and notations were made. This time, participants were instructed that the focus is on team performance, not on their individual performance and that only their team solution would be evaluated. At the end of the work session, participants individually filled out a post-experimental questionnaire. The task completion process was videotaped and later transcribed fully.

Measures

Individual Performance. To arrive at a performance measure for participants' individual design task performance, we evaluated the hand-written design solutions produced for the Library Management Problem from the first part of the study.

Participants' design solutions were - following a procedure from Sonnentag (1998) - rated along five criteria (completeness, modularity, comprehensibility, algorithm quality, and detail) on a 5-point scale ranging from 1 (very poor) to 5 (excellent) which we consequently reduced to one overall measure of design task performance (Cronbach's α = .92). For reliability analysis, a second rater assessed 20 randomly chosen design solutions. Interrater reliability for the overall measure was high, resulting in a coefficient of r = .83. All further analyses were based on the categorization provided by the more experienced rater.

For each dyad, we determined the team member with the highest performance score in the Library Management Task. In our analyses, we used this person's performance score as a measure of high individual performance. If both members had a similar score, we randomly chose one team member as high performer.

Similarly, for each dyad, we determined the team member with the worse performance score in the Library Management Task. This person's performance score was used as a measure of moderate individual performance. If both members had a similar score, we randomly chose one team member as low performer.

Team Performance. To arrive at a performance measure for dyads' team performance we evaluated the hand-written design solutions for the Financial Management Problem. Analogous to individual performance, participants' design solutions were rated by five criteria (completeness, modularity, comprehensibility, algorithm quality, and detail) on a 5-point scale ranging from 1 (very poor) to 5 (excellent) which we consequently collapsed into one overall measure of design task performance (Cronbach's α = .90). For reliability analysis, a second rater assessed 20 randomly chosen design solutions. Interrater reliability for the overall measure was r = .73. Consistent with other recent research (e.g., Gigone & Hastie, 1997; LePine, Hollenbeck, Ilgen, & Hedlund, 1997), we consequently transformed the team design task performance by using the squared difference, that is, we computed the squared difference between team performance and the maximum team performance. These values were reversed so that high scores represent high team performance.

Planning. We assessed the amount of planning per dyad by analyzing the content of the verbal transcripts. Video-recorded protocols from the Financial Management Task were transcribed verbatim and segmented with each phrase constituting a segment (cf. Sonnentag, 1998). The average number of segments was M = 483.38 segments (SD = 109.41). Two planning categories were differentiated: Planning ahead (i.e., reflecting and deciding on the future course of action; thinking about what to do first and what to postpone) and local planning (i.e., thinking about and communicating the next step without extensively reflecting on it) (Sonnentag, 1998). An example of planning ahead is "We should discuss this topic after we have made a first design." and an example of local planning is "Okay, let's start writing down our solution.". Again, for reliability analyses, 20 randomly chosen transcripts were assessed by two raters. The categories consisted of *Planning*, *Planning Ahead*, and *Other Statements*. We calculated the amount of the percentage of what each person said per category. We obtained a satisfactory Cohen's Kappa of k = .71 (Fleiss, 1981).

Control Variables. Control variables included in our analyses were number of solutions, goal commitment, and months of professional experience.

Number of solutions. The instruction for the cooperative Financial Management task asked for producing one combined solution. However, some dyads did not produce any written solution (N = 2), some produced two similar but separate solutions (N = 16), and most produced - as required - one combined solution (N = 32). To control for any differences regarding team performance due to compliance to task instruction, we controlled for the number of solutions a dyad produced.

Goal commitment. Several studies emphasized the importance of motivational processes as determinants of purposeful actions and work performance (Seo, Feldman Barrett, & Bartunek, 2004). Therefore, we included goal commitment as a control variable. We measured goal commitment with eight items from a scale developed by Hollenbeck, Klein, and O'Leary (1989). A sample item was "I was strongly committed to pursuing the team's goal". The items were answered on a 5-point scale ranging from 1 = not true at all to 5 = very true. Cronbach's α was .70.

Professional experience in software design. To ensure that differences in team performance were not due to length of experience in professional software design, participants were asked to indicate how many months of experience in professional software design (e.g., as an intern or working student) they possessed.

Results

Means, standard deviations, and zero-order correlations between study variables are presented in Table 1.

Table 1: Means, Standard Deviations, and Intercorrelations of the Main Study Variables

	M	SD	1	2	3	4	5	6	7
1 High performers' library management score	2.79	1.04							
2 Moderate performers' library management score	1.81	0.88	.54**						
3 Team performance [a]	9.96	4.89	.27	.15					
4 Number of solutions	1.26	0.52	-.04	.03	.36**				
5 Goal commitment	3.91	0.39	.01	.03	.04	-.13			
6 Professional experience	9.50	11.03	.29*	.15	-.16	.03	.17		
7 Planning ahead	0.44	0.57	.08	.09	.15	-.05	.12	-.01	
8 Local planning	4.28	1.75	.26	-.08	.32*	-.02	-.32*	-.08	.09

Note. N = 53 dyads; ** $p < .01$. * $p < .05$; [a] Team performance is the reversed squared difference between actual team performance and maximum team performance

Test of the Hypotheses

To test our hypotheses we ran hierarchical regression analyses. Hypotheses 1 predicted high individual performance to be positively related to team performance. Hence, we regressed team performance on individual performance (Table 2). In Step 1, we entered the control variables (number of solutions, goal commitment, and months of professional experience in software design) into the equation. In Step 2, we entered the performance score of the high performer in the dyad and the performance score of the moderate performer in the dyad. According to Hypothesis 1, high individual performance was positively related to team performance ($\beta = .39$, $p < .05$). Moderate individual performance was not related to team performance ($\beta = -.03$, *n.s.*).

Table 2. *Hierarchical Regression Predicting Team Performance from Individual Performance*

	Predictor variables	B	SE B	β	R^2	ΔR^2
Step 1	Control variables				.17*	.17*
	Number of solutions	3.58	1.22	.38**		
	Goal commitment	1.52	1.68	.12		
	Professional experience	-.08	.06	-.19		
Step 2	Individual performance				.30**	.12*
	High performer	1.81	.71	.39*		
	Moderate performer	-.19	.81	-.03		

Note. $N = 53$ dyads. ** $p < .01$. * $p < .05$.

Hypotheses 2 and 3 addressed the relationship between planning behavior and team performance. More specifically, in Hypothesis 2 we assumed that planning ahead will be positively related to team performance and in Hypothesis 3 we assumed that local planning will be positively related to team performance. To test these hypotheses, we regressed team performance on local planning and on planning ahead (Table 3). In Step 1, we entered the control variables (number of solutions, goal commitment, and months of professional experience) into the equation, and in Step 2 we entered local planning and planning ahead. Analyses revealed that local planning was related to team performance in the expected direction (β = .38, p < .01) but planning ahead was not (β = .10, *n.s.*). Thus, Hypothesis 3 was confirmed whereas Hypothesis 2 was not.

Table 3. *Hierarchical Regression Predicting Team Performance from Planning Ahead and Local Planning*

	Predictor Variables	B	SE B	β	R²	ΔR²
Step 1	Control variables				.17*	.17*
	Number of solutions	3.58	1.22	.38**		
	Goal commitment	1.52	1.68	.12		
	Professional experience	-.08	.06	-.19		
Step 2	Planning behavior				.33**	.15**
	Planning ahead	.88	1.04	.10		
	Local planning	1.07	.36	.38**		

Note. N = 53 dyads. ** p < .01. * p < .05.

In Hypothesis 4 we proposed that individual performance would be related to planning ahead behavior. Similarly, we assumed in Hypothesis 5 that individual performance will be related to local planning behavior. To test Hypothesis 4 and 5, we regressed local planning and planning ahead on individual performance in Step 2, after entering the control variables in Step 1. Analyses showed that high individual performance was not related to planning ahead (β = .05, *n.s.*) (Table 4). Therefore, Hypothesis 4 was not supported. High individual performance was positively related to local planning (β = .46, p < .01) (Table 5), supporting Hypothesis 5.

Table 4. *Hierarchical Regression Predicting Planning Ahead from Individual Performance*

	Predictor Variables	B	SE B	β	R^2	ΔR^2
Step 1	Control variables				.02	.02
	Number of solutions	-.03	.16	-.03		
	Goal commitment	.17	.22	.12		
	Professional experience	.00	.01	-.03		
Step 2	Individual performance				.03	.01
	High performer	.03	.10	.05		
	Moderate performer	.04	.11	.07		

Note. $N = 53$ dyads.

Table 5. *Hierarchical Regression Predicting Local Planning from Individual Performance*

	Predictor Variables	B	SE B	β	R^2	ΔR^2
Step 1	Control variables				.11	.11
	Number of solutions	-.21	.45	-.06		
	Goal commitment	-1.48	.63	-.33*		
	Professional experience	.01	.02	-.02		
Step 2	Individual performance				.25*	.14*
	High performer	.77	.26	.46**		
	Moderate performer	-.60	.30	-.30		

Note. $N = 53$ dyads. ** $p < .01$. * $p < .05$.

We finally assumed that the relationship between high individual performance and team performance would be mediated by planning ahead (Hypothesis 6) and local planning (Hypothesis 7). To test for mediation we followed the mediation criteria set forth by Baron and Kenny (1986). These criteria are: (a) The independent variable must be related to the dependent variable, (b) the independent variable must be related to the mediator, and (c) the mediator must be related to the dependent variable. Finally, when controlling for the influence of the mediator, the relationship of the independent and the dependent variable must be substantially weakened. As shown by testing Hypothesis 1, we found support for criteria (a): high individual performance was positively related to team performance. For local planning, criteria (b) and (c) were also confirmed as tested with Hypothesis 5 and Hypothesis 3, respectively. To test if condition (d) was met, we looked at the combined effects of the predictor and mediator on the outcome variable (Table 6). When both predictor and mediator were entered into the equation, only local planning remained significant. High individual performance was no longer related to team performance.

To test if the reduction in regression weight for the predictor high individual performance was statistically significant, we computed the Sobel test (Preacher & Leonardelli, 2001; Sobel, 1982). The reduction in regression weight for the predictor high individual performance from $\beta = .39$ to $\beta = .23$ was marginally significant ($Z = -1.89$, $p < .10$). According to Baron and Kenny (1986), this suggests that local planning partially mediated the effect of individual performance on team performance. Thus, Hypothesis 7 was confirmed. With respect to Hypothesis 6 we did not compute a regression analysis controlling for the influence of planning ahead, given that criteria (b) and (c) have not been met.

Table 6. *Mediation by Local Planning*

	Predictor Variables	B	SE B	β	R^2	ΔR^2
Step 1	Control variables				.17*	.17*
	Number of solutions	3.58	1.22	.38**		
	Goal commitment	1.52	1.68	.12		
	Professional experience	-.08	.06	-.19		
Step 2	Mediation by local planning				.38**	.21*
	High performer	1.09	.73	.23		
	Moderate performer	.37	.81	.07		
	Local planning	.93	.38	.33*		

Note. $N = 53$ dyads. ** $p < .01$. * $p < .05$.

In summary, results showed that high individual performance significantly predicts team performance, as assumed in Hypothesis 1. In contrast to Hypothesis 2, planning ahead was not related to team performance. Local planning was related to team performance, providing support for Hypothesis 3. Contrary to Hypotheses 4, high individual performance was not related to planning ahead. As predicted in Hypothesis 5, we found that high individual performance was positively related to local planning. With respect to mediation, we found no support for Hypothesis 6, predicting a mediation effect of planning ahead for the relationship between high individual performance and team performance. In line with our assumption, we found that the relationship between high individual performance and team performance was partially mediated by local planning, providing support for Hypothesis 7.

Discussion

The main aim of our study was to examine if and how individual characteristics and team characteristics are inter-related. In line with action theory (Frese & Zapf, 1994; Hacker, 1998; Tschan, 1995) we argued that planning behavior helps to improve team performance.

The results showed that individual performance is positively related to team performance. More specifically, we could provide evidence that it is the high performer's individual performance and not the moderate performer's individual performance that positively relates to team performance. Regarding the process, results reveal that only local planning was positively related to team performance, not planning ahead. Furthermore, we found that only the high performer's individual performance was positively related to local planning, not the moderate performer's individual performance. Individual performance, either high or moderate, was unrelated to planning ahead. Finally, we found evidence that the relationship between high and moderate performance was partially mediated by local planning. Surprisingly, planning ahead did not function as a mediator between individual performance and team performance.

Local planning plays a crucial role in teams because in order to work effectively team members have to communicate and coordinate their next action steps. A team that communicates the next action steps shows a pattern of common information sharing that resembles the cognitions of an individual who plans his or her actions consecutively (Tschan, 1995). Local planning ensures that the team is focusing on one problem at a time, that team members know what has to be done next, and that they exchange information about how the next problems should be approached.

We did not find support for planning ahead as playing an important role in promoting team performance. One explanation for the fact that planning ahead was not helpful for accomplishing the software task might be that the task did not have to be completed in a fixed sequence (cf. Guindon, 1990). Other tasks such as highly complex simulations and managerial tasks might require more planning ahead (e.g., Klemp & McClelland, 1986) compared to software design tasks. Another reason for the fact that planning did not emerge as a relevant mediator in this study might be due to the laboratory situation. Participants knew that they were to produce a team solution within a limited amount of time. Spending too much time on planning the future course of action might not have been regarded to be the best strategy. Future studies should replicate this study using tasks from different domains with varying complexity and more extensive time frames.

There was evidence that local planning partially mediated the relationship between high individual performance and team performance. The fact that there was no full mediation suggests potential other mediators that we did not include in our model. One could think of other mediators, as for example cohesiveness, potency, or goals (Guzzo & Dickson, 1996). Mullen and Copper (1994) for example reported a meta-analytic integration of the direct relationships between cohesiveness and performance. They concluded that the effect of cohesiveness on performance was highly significant. Potency, defined as the team members' collective belief that they can be effective (Guzzo, Yost, Campbell, & Shea, 1993), has also been shown to be positively related to team performance. For example, Hecht, Allen, Klammer, and Kelly (2002) found that potency predicted performance over and above group member ability. Future research might fruitfully investigate additional variables that possibly mediate between individual expertise and team performance.

Strengths and Limitations

There are strengths in this study that emphasize the importance of the findings. First of all, it was taken care to exclude bias resulting from self-ratings. Therefore, to obtain the core variables, objective data by different measures was gathered eliminating common-source bias (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). More specifically, ratings of participants' solutions from two raters were used.

Furthermore, verbal protocol data was taken to measure planning behavior as process variables. The approach of using verbal protocol data for process analyses seems to be appropriate and made it possible to analyze planning behavior at a micro analytic level (Ericsson & Simon, 1993).

Regarding the tasks used in this study, we believe that well-suited tasks were employed. The individual software design task was complex enough so that high performers could show their competencies. If we had used a simpler task participants presumably would have used a standard procedure that might have obscured differences between high and moderate performers. Additionally, the team software design task allowed teams to accomplish a complex task while having high levels of autonomy in order to be able to develop viable approaches for task accomplishment. Members had to conjointly contribute to the task in order to attain a positive outcome.

While the findings have implications for understanding how individual and team performance are inter-related, it is important to note the limitations of the study. As a possible weakness one might criticize the use of dyads. One might doubt if the same processes occur in dyads that would apply to larger teams. Despite some possible differences between dyads and larger teams (i.e., the restricted number of communication channels, the lack of possibilities for coalition formation, and the dearth of elaborated team structures, Levine & Moreland, 1990) this study shows that a high performer can also be influential in dyads. Previous research has also shown that the path of solution development and communication structure in dyads and larger teams are quite similar (Tschan, 2002). Nevertheless, future research should investigate the relationship of individual performance and team performance in larger teams.

A possible drawback of the study is the relatively small sample size. However, it should be noted that other studies that used verbal protocol data as well as dyads used samples with the same or even smaller size (e.g., Bayazit & Mannix, 2003; Tschan, 2002; Weldon, Jehn, & Pradhan, 1991). Additionally, one should keep in mind that the combination of studying dyads by using verbal protocol data is very rare (for exceptions see for example Tschan, 1995; Tschan, 2002). More importantly, the effects were found despite the small sample size indicating that the effect sizes were not negligible. For reasons of practicability, the use of thinking aloud analysis restricted the sample to a limited number of participants.

Furthermore, one might question if the composition of the dyads was appropriate. Participants were randomly matched into dyads without knowing in advance who is a high or moderate performer in software design. Thus, there was not always equal difference between the performance levels of the dyads' members. In fact, individual performance levels in dyads were moderately correlated. The correlation is due to the fact that high and moderate performance was not established experimentally. Both participants had experience in computer science and the way of determining the best and average performer yielded a moderate correlation between the scores of the two participants within one dyad. The advantage of this approach to assess participants' competence in software design is that individual performance was reported which has been acquired by participants during a longer time-frame in a field that is meaningful for participants. This ensures a certain degree of external validity. The disadvantage is that there was not the same level of performance in each dyad. To overcome the problems associated with dyad composition, future studies might therefore manipulate individuals' performance level.

Implications for Theory and Practice

From a theoretical perspective, it is not only interesting *if* individual performance is related to team performance, but also *how* individual performance is related to team performance. This research contributes to a better understanding of why high performers are influential in teams. Local planning emerged as an important factor for enhancing team performance. The most common framework for team performance is an input-process-output model (I-P-O-model; e.g., Hackman, 1987; Hackman & Morris, 1975). Recently, Ilgen et al. (2005) criticized that an I-P-O framework limits research by suggesting a single-cycle linear path from inputs through outcomes and thereby neglecting feedback-loops. They suggest that it would be better to treat former team outputs such as team performance as team inputs to the future team process. Additionally, Ilgen et al (2005) state that it could be possible that there is no linear progression of one category to the next (I-P-O) but that there are possibly also interactions between inputs and processes, in this case between individual expertise and local planning. Future research should regard the notion that teams are complex and dynamic systems and take cyclical feedback into account.

From a practical perspective, identifying team processes that mediate between individual performance and team performance is useful for training and selecting individuals as team members. Trainees should learn a working style incorporating local planning. One could for example make use of the deliberate practice approach (Ericsson, Krampe, & Tesch-Römer, 1993). According to this approach, experts engage continuously in deliberate and extensive practice that leads to enhanced performance. Special features of experts while working on tasks - such as their planning behavior - could be trained by a teacher or coach to improve other team members' performance. Working style during task accomplishment could also be used as a predictor when selecting individuals for teams. One might put applicants in a situation that requires them to work on a task cooperatively. Afterwards, raters could assess the applicant's behavior in this team setting and base their decision for selecting certain individuals for teams on these observations.

Conclusion

Overall, this study contributes to previous research by examining the relationship between high individual performance and team performance and by investigating the question of *why* some teams are more effective than others. Findings suggest that high individual performance is positively related to team performance and that planning behavior is a meaningful factor in explaining the relationship between high individual performance and team performance. We hope that the current results spark additional interest in local planning and the effects it has on team outcomes.

Chapter 3: The Effects of Actual and Perceived Expertise on Team Performance: An Experimental Study

Summary

In this study we examined how both actual and perceived individual expertise impact team performance. Knowledge about which individual factors are related to team performance is relevant for personnel selection, training, and staffing of teams. We used a 2 x 2 between-subject experimental design with the factors actual individual expertise (high vs. moderate) and perceived individual expertise (high vs. moderate). Actual individual expertise was manipulated by a 90-minutes training and perceived individual expertise by alleged information on the cooperation partner's expertise. After manipulation, participants (N = 200) worked cooperatively in dyads on an electronic business task which served as a measure for team performance. Results indicated that dyads high in actual expertise (i.e., with one team member high in actual expertise) had higher scores on the teams' task solution compared to dyads moderate in actual expertise (Cohen's d = .91 for overall team performance). Results did not show any differences between dyads high in perceived expertise compared to dyads moderate in perceived expertise. Furthermore, there was no interaction effect for actual and perceived expertise with respect to dyads' team performance. The results support the notion that actual expertise is one of teams' most important resources, and that it is preferable to consider actual expertise compared to perceived expertise when selecting and composing teams.

Introduction

In contemporary organizations, teams are widely used (Gully et al., 2002; Ilgen et al., 2005; Poole et al., 2004). In the team literature, several team member characteristics or inputs such as personality or ability are seen to impact team performance (e.g., Ilgen et al., 2005). In this study, we refer to individual expertise as an input factor. Knowledge about which aspects of individual expertise are relevant for team performance is extremely useful for personnel selection and training. However, there is a lack of research dealing with the question of how individual team member characteristics are related to team performance (Klein & Kozlowski, 2000).

When composing teams, managers can base their decision either on actual expertise (i.e., knowledge about facts and procedures and an understanding of the task's requirement), or on perceived expertise (i.e., how others observe someone's performance) (Zysberg & Nevo, 2004). It is theoretically and practically interesting which factor is most important for successful team performance and how they combine, respectively.

To date, there have been studies that have addressed the question of actual and perceived expertise separately: First, empirical evidence suggests that having knowledgeable team members (for convenience we will refer to them as *actual experts*) positively relates to team performance (cf. for a review Stewart, 2006); second, there is evidence that regarding someone as an expert (for convenience we will refer to them as *perceived experts*) influences behavior and performance in teams (Berger, Fisek, Norman, & Zelditch, 1977; Rosenthal & Jacobsen, 1966); third, research on recognition and utilization of expertise has emphasized that for successful team performance actual expertise has to be necessarily perceived by the other team members (cf. for a review Ilgen, Hollenbeck, Johnson, & Jundt, 2005).

Although research has shown that actual expertise, perceived expertise, and a team's ability to perceive actual expertise is positively related to team performance (Baumann & Bonner, 2004; Bonner et al., 2002; McNatt & Judge, 2004; Stasser, Stewart, & Wittenbaum, 1995; Stewart & Stasser, 1995), to our knowledge there is no experimental study that has examined whether the strongest predictor for team performance is actual expertise, perceived expertise or a combination of both. It is certainly plausible to assume that circumstances under which both actual expertise and perceived expertise are high are positively related to team performance, and this combination is better than one of these input factors alone. However, a direct test that experimentally establishes these factors and that simultaneously examines the effects of actual and perceived expertise is needed.

The goal of the present study is to expand our understanding of the factors that are needed to achieve high team performance. Specifically, we will address three issues: *(1)* if actual expertise is related to team performance; *(2)* if perceived expertise is related to team performance; *(3)* if the combination of actual and perceived expertise is related to team performance. A better understanding of which factors impact team performance is crucial for example for selection and training purposes. Managers could better decide if the focus in staffing or training situations should be on actual expertise, perceived expertise, or on a combination of both aspects of expertise.

Expertise

What is meant by expertise? Most researchers agree with the definition of expertise as “outstanding performance” (Ericsson & Smith, 1991, p.2). There are two major concepts of expertise. The *experience approach* builds the criterion of expertise on length of experience (e.g. Chi et al., 1982; Wiedenbeck et al., 1993) and thereby compares experts with novices, i.e., persons who have less experience in a certain domain. In contrast, the *excellence approach* assumes that experience might be necessary to show high performance, but more importantly one has superior knowledge in a certain domain (Ericsson, 2005; Sonnentag, 1998). In this study, the excellence approach is applied, as this criterion has been shown to be more efficient compared to experience (Summers, Williamson, & Read, 2004).

Actual individual expertise and team performance

The possession and application of expertise is a crucial prerequisite for successful task accomplishment. This is true for individual as well as for cooperative settings. Input-process-output models of team performance (Hackman & Morris, 1975; Ilgen et al., 2005; McGrath, 1984) assume that inputs lead to processes that in turn influence the output. Hackman (1987) recommended to staff teams with as many talented individuals as possible. On the individual level, research could identify a variety of differences between experts and non-experts. They differ for example with respect to their planning behavior, problem comprehension, the domain-specific knowledge (cf., for reviews Ericsson & Lehmann, 1996; Sonnentag, Niessen, & Volmer, in press). There are some studies in expertise research that have investigated how experts behave in team settings. These studies offer some explanations for the processes by which experts have a positive impact on team performance. For example, Curtis, Krasner, and Iscoe (1988) investigated experts' behavior in software development teams and found that experts show superior communication skills. Sonnentag (1995) found that high performing software professionals were described by their co-workers as highly socially competent. In a study at the Bell Laboratories, Kelley and Caplan (1994) demonstrated that excellent managers possessed better functioning networks compared to moderate performers. Sonnentag (2001) found in a field study that experts displayed cooperation competencies especially in unstructured meetings. Experts showed process-regulating behavior such as planning and feedback seeking when the situation demanded it.

As experts possess superior knowledge and exceptional competence in their domain (Ericsson & Smith, 1991), we consider experts to be beneficial for team performance. There is some research that supports this notion. Bottger and Yetton (1987) for example found in a laboratory study with managers and MBA students that team performance was strongly determined by member task ability and member use of task knowledge. Similarly, Bonner et al. (2002) showed in an experiment that experts exert more influence in teams than other members and do positively influence team decision making and team performance.

Taken together, these studies suggest that experts are active and influential in team settings and that thereby they can influence team performance. In sum, we expect that actual individual expertise has a positive effect on team performance.

Hypothesis 1: Actual individual expertise will have a positive effect on team performance.

Perceived individual expertise and team performance

Besides actual individual expertise, perceived individual expertise is expected to have a positive impact on team performance. The assumption draws on status characteristics theory and on the theory of self-fulfilling prophecy.

The status characteristics theory (Berger, Cohen, & Zelditch, 1972; Berger et al., 1977; Berger, Rosenholtz, & Zelditch, 1980) provides a basic model of how team members' characteristics organize social interaction. The theory states that individuals hold "performance expectations" for one another, about their own and other team members' ability to contribute to the team task. These performance expectations are driven by the "status" that team members assign to the various personal characteristics of the team members on the basis of existing information (e.g., past performance) and visible attributes (e.g., gender). In status characteristics theory, a personal characteristic of a team member that has been associated with task competence has therefore become a status characteristic or a status cue (Berger et al., 1980). Status cues are believed to provide information about an individual's competence or expertise with respect to a clearly defined task (Berger et al., 1977). These status cues are assumed to inform the performance expectations team members develop for each other. Performance expectations in turn, have been shown to be directly associated with opportunities for task involvement and influence in task teams (Berger et al., 1972; Berger et al., 1977; Bunderson, 2003). Referring to this study, it is expected that information on perceived expertise is a status-organizing process determining how team members will interact.

Although definitions sometimes vary, theorists tend to agree that status characteristics have three major components (Anderson & West, 1998). First, high status members are more prominent and receive more scrutiny (Chance, 1967; Fiske, 1993). This implies that high status team members are more central and will be considered more frequently as a source for information that might be beneficial in order to solve the team task. Secondly, they are more respected than lower status members (Barkow, 1975; Eibl-Eibesfeldt, 1989; Goldhamer & Shils, 1939). Being more respected might lead to the fact that the perceived expert's input is weighted higher compared to other team members' input. Often, other team members offer their resources to the perceived expert, as they expect him or her to be able to perform the team task (Berger et al., 1977). Third, high status members are more influential in team discussions and are allowed more control over the team discussions and processes (e.g., Bales, Strodtbeck, Mills, & Roseborough, 1951; Berger et al., 1972; Littlepage, Schmidt, Whisler, & Frost, 1995). Driskell and Mullen (1990) performed a meta-analysis and found that performance expectations fully mediated the relationship between status cues and influence. Similarly, Littlepage et al. (1995) found in a laboratory study that perceived expertise mediated the relationship between members' characteristics and their influence. Status characteristics theory offers a useful framework for explaining how someone who is perceived to be an expert earns high status in a team. Implications of perceived experts' status are that they enact a more proactive role and command more of the team's resources so that it can be expected that perceived experts attain better task performance competencies (Milanovich, Driskell, Stout, & Salas, 1998).

The self-fulfilling prophecy theory or research on the Pygmalion effect (Merton, 1948; Rosenthal & Jacobsen, 1966) provides strong evidence that expectations from others can actually influence people's behavior (Eden, 1990; Harris & Rosenthal, 1985). Consequently, this research provides an explanation for how other's expectations might in turn improve the perceived expert's own performance. Merton (1948) was the first who proposed the idea that beliefs or expectations about a person might lead to their own fulfillment. Rosenthal and Jacobsen (1966) demonstrated that teacher expectations could shape individual student achievement. This finding has been firmly established in educational psychology, showing that raising teacher expectations improves pupil achievement (Babad, 1993; Dusek, Hall, & Meyer, 1985; Harris & Rosenthal, 1985). There also has been consistent evidence of the existence of the self-fulfilling prophecy in non-school organizational settings. In organizations, it has been shown that raising a manager's expectations towards a subordinates' performance actually raises their performance (Eden, 1990, 1993; McNatt, 2000). Meta-analytic evidence revealed an average effect size of r =. 30 for the magnitude of the expectancy effect across settings (Rosenthal, 1998, 2002).

Several theoretical models tried to explain the process of self-fulfilling prophecy (Brophy & Good, 1974; Cooper & Good, 1983; Rosenthal, 1974). It is supposed to be a three-step-process: First, a perceiver has a certain expectation of another person; second, the perceiver behaves in a way that is consistent with those expectations; third, the target adjusts his or her behavior according to the perceiver's expectations. Concerning the mediating processes that are responsible for the relationship between expectations and performance, a four-factor "theory" was proposed (Rosenthal, 1973, 1974). The first factor refers to a positive "climate" that is created by the perceiver. Second, it is assumed that the perceiver offers more "input" to the high expectancy target. Third, there is a tendency to give greater opportunities for responding or "output". And finally, perceivers give a more differentiated "feedback" to the target that helps to improve in the future. Thus, the initial high expectations translate into better performance by supportive behavior of the perceiver. High perceived expertise is expected to enhance this person's influence in the team (Thomas-Hunt, Ogden, & Neale, 2003) and thus offers more opportunities to improve actual expertise by communicating about problems (Sonnentag & Kleine, 2000). Furthermore, perceived expertise has been shown to have a positive effect on an individual's confidence (Trafimow & Sniezek, 1994) which is an important prerequisite for successful task accomplishment. For this study, the status characteristics theory and the theory of self-fulfilling prophecy imply that expectations toward a team member who is perceived to be an expert might change his or her behavior which leads to better individual performance that in turn improves team performance. Taken together, these arguments propose that perceived expertise increases team performance.

Hypothesis 2: Perceived individual expertise will have a positive effect on team performance.

Combination of actual individual expertise and perceived individual expertise

As argued above, we assume that actual individual expertise and perceived individual expertise alone can positively predict team performance. Furthermore, we expect that the best team outcome will be achieved when both actual and perceived individual expertise are present. Teams in which the actual expert is also perceived as an expert should show the highest team performance. On the other hand, teams in which the actual expert is not perceived as an expert will presumably perform worse. Similarly, teams with someone being erroneously perceived as an expert will probably yield lower team performance compared to teams that rely on the 'real' expert. Successful teams will have to identify their best team member and use the advice, suggestions, and opinions of this more expert team member when working on a task. In team literature there is evidence that recognition and utilization of experts' knowledge leads to better team performance (Baumann & Bonner, 2004; Bunderson, 2003; Henry, 1995).

Basically, three research streams that have addressed recognition and utilization of expertise in work teams are considered in more detail: the shared mental models approach, the distributed knowledge approach, and the expert influence approach.

The shared mental knowledge approach refers to organized knowledge structures that allow individuals to interact with their environments (Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000). Originally, this approach was developed for individuals. In it, mental models help individuals to recognize components of the environments and to create expectations about what is likely to occur next. The idea of shared mental models has also been transferred to the team setting (e.g., Cooke, Kiekel, Salas, & Stout, 2003; Klimoski & Mohammed, 1994). These mental models can imply a representation of the individual's interaction with a team and thus influences an individual's behavior in a team (Hinsz, Tindale, & Vollrath, 1997). Teams who possess an accurate shared mental model are expected to be better able to detect and recognize salient cues, as for example actual expertise, and are therefore proficient to make decisions, solve problems, and design solutions (Cooke et al., 2003).

The distributed knowledge approach is concerned with the question of whether and under what conditions team members are able to pool unshared information in order to make accurate decisions. Unshared information is uniquely held knowledge and shared information is information every team member holds (Stasser & Titus, 1985). Research has shown that teams are generally quite poor at using and integrating unshared information and tend to exchange shared information (Larson, Franz, Christensen, & Abbott, 1998; Stasser & Titus, 1985), but that they achieve a better decision when they are given explicit cues about who knows what (Stasser, Stewart, & Wittenbaum, 1995; Stewart & Stasser, 1995). Building the bridge to this study, unshared information is expected to be possessed by the actual expert. If this unshared information is brought into team discussion, team performance is expected to be enhanced. As unshared information has to be cued in order to improve a team's performance, the condition in which actual expertise is matched with perceived expertise should lead to the highest team performance.

The expert influence approach refers to the ability of team members to detect the best member of their team and whether experts are able to influence team performance and team decision making. Empirical evidence points in the direction that teams are not very good at identifying their best team member (Littlepage et al., 1995). Often, they erroneously rely on more obvious cues such as dominance (Bales, 1953; Littlepage et al., 1995). Research suggests that teams perform better when they receive feedback on team members' performance (Henry, 1995), when they have an identified expert (Bonner et al., 2002; Franz & Larson, 2002), and when teams have been working together for a longer time (Larson et al., 1998). Again, teams that identify their best team member (i.e., the actual expert) can create opportunities for the best member to yield influence on the group process which in turn improves team performance.

Taken together, these arguments imply that under conditions in which existence of actual expertise is paired with perceived expertise or - stated differently - when the expert's knowledge is recognized and the probability of using his or her knowledge is enhanced, team performance should benefit.

In sum, based on these arguments we assume that team performance will be best when both actual individual expertise and perceived individual expertise is high.

Hypothesis 3: Actual individual expertise and perceived individual expertise will interact in a way that best team performance is achieved when both actual and perceived expertise is high.

Method

Overview

To test our hypotheses, we conducted an experiment in which we manipulated actual and perceived expertise. Each experimental session lasted approximately 4 hr and included four phases. In the first phase, we collected questionnaire data on demographics, possible third variables and delivered an internet knowledge test. In the second and third phase, we manipulated actual and perceived task expertise. Until then, participants worked individually. In the fourth phase, participants worked cooperatively in dyads on an e-business task. An overview of the course of the experiment is depicted in Figure 2.

<table>
<tr><th colspan="2">Participants A</th><th colspan="2">Participants B</th></tr>
<tr><td>Actual Expertise High</td><td>Actual Expertise Moderate</td><td>Perceived Expertise High</td><td>Perceived Expertise Moderate</td></tr>
<tr><td colspan="4">(1) Introductory Phase
General Questionnaire and Internet Knowledge Test and “Evaluation” of the Internet Knowledge Test</td></tr>
<tr><td colspan="4">(2) Manipulation Phase Perceived Expertise</td></tr>
<tr><td colspan="2">No Information</td><td>Information on Participant A as excellent performer</td><td>Information on Participant A as moderate performer</td></tr>
<tr><td colspan="4">(3) Manipulation Phase Actual Expertise</td></tr>
<tr><td>E-Business Training</td><td>New Media Training</td><td colspan="2">New Media Training</td></tr>
<tr><td colspan="4">(4) Team Task
E-business Task (Participant A + Participant B)</td></tr>
</table>

Figure 2. *Course of the experiment (Study 2)*

Participants

The study included 208 volunteer students majoring in a range of non-technical studies from two German universities. Participants were contacted via mailing lists and flyers distributed on the university campus. The study was introduced as part of a research project concerned with innovation in New Media. For participating, students received 30 Euros (approximately $US40). Payment was not contingent on task performance. Complete and useable data existed from 200 participants and are reported here. Mean age was 24.16 years (*SD* = 5.32). The majority (72 %) of all participants were female. On average, participants were in their third year of study (*SD* = 2.90). Regarding participants’ experience with e-business, the majority of participants (78 %) reported to have no experience, 21.5 % indicated to have minor to moderate experience, and 0.5 % stated to have considerable experience. All dyads were same-gender dyads composed of either two men or two women. The decision to have participants work with only one other person of the same gender was based on our desire to test our ideas in the most controlled manner possible. Data about previous acquaintance of team members as well as previous shared work experience revealed that none of the participants had worked with each other before and that 77 % of the participants had not seen each other before.

Experimental Design

We used a 2 x 2 design with actual individual expertise (moderate vs. high) and perceived individual expertise (moderate vs. high). Each participant was randomly assigned to one of the four experimental conditions (actual expertise moderate and perceived expertise moderate; actual expertise high and perceived expertise moderate; actual expertise moderate and perceived expertise high; actual expertise high and perceived expertise high), so that there were 50 participants in each condition (see Table 7). In the fourth phase of the experiment participants worked together in dyads. The dyads consisted of two types of participants: Participants *A* and participants *B*. Participants *A* were manipulated on the factor actual individual expertise and Participants *B* were manipulated on the factor perceived individual expertise.

Table 7. Study Design

Perceived expertise	Actual expertise	
	Actual expertise moderate	Actual expertise high
Perceived expertise moderate	*Participant A*: New Media training *Participant B*: Information on *(A)* as moderate performer	*Participant A*: E-business training *Participant B*: Information on *(A)* as moderate performer
Perceived expertise high	*Participant A*: New Media training *Participant B*: Information on *(A)* as excellent performer	*Participant A*: E-business training *Participant B*: Information on *(A)* as excellent performer

Note. *Participant A* never received any performance information on *Participant B*; in all cases, *Participant B* received the New Media training.

Procedure

On arrival, participants were welcomed by two experimenters and brought into two separate experimental rooms. Then, participants completed a questionnaire on demographic variables and on their knowledge about the internet. After completion of this questionnaire, participants were given another questionnaire collecting data on possible third variables. Additionally, participants in the perceived expertise condition were told that meanwhile participants' knowledge about the internet would be evaluated. Thus, one experimenter collected the questionnaires and left the experimental room. After a short time, the experimenter in the perceived expertise condition enacted the perceived expertise manipulation. Participants were told that they would later work on a team task with the other participants either said to have excellent or moderate knowledge about the internet. To emphasize the manipulation, a profile of the alleged results of the internet knowledge test was presented. Participants in the actual expertise condition did not receive any information on the partner's expertise. Then, all participants were told that they would receive additional information on the team task topic. To prevent information exchange about the training during task completion, participants were instructed that they could use the information but should not talk about it when working together because only they received useful information. At this time, actual expertise was manipulated by giving participants either a folder with information on e-business or on New Media. Only the folder containing information on e-business was useful for the team task to be accomplished later. After 90 minutes, the folder and participants' notes were collected. The experimenter reiterated the information on the partner's internet knowledge in the perceived expertise condition and asked participants to fill out another questionnaire. This questionnaire served as a manipulation check for actual expertise. Afterwards, participants were brought together in one experimental room and were given the team task. It was emphasized that they were to produce a joint solution. Fifteen minutes before the end of the task participants were reminded to write down their solution. After participants had worked on the task for 45 minutes, the written task solutions were collected and the participants were asked to respond to a brief questionnaire in two separate experimental rooms. The experimenters then explained the purpose of the research and answered any questions participants had.

Task

Participants were required to create a website for the internet that organizes business processes online. More specifically, they were asked to start an electronic business (e-business). The task was designed in a way that specialized, domain-specific knowledge as received during e-business training should be applied.

In the beginning, participants received a sheet with the task. Participants were asked to make a concept for an internet-based bike rental company. Delivery and return of the bikes should take place in two university cities and three tourist cities. Participants were given 45 minutes to complete the task. In the first 30 minutes, participants were asked to discuss and take notes on their solution, followed by a section of 15 minutes in which they were to write down their joint solution. It was emphasized that participants should write down their joint solution in contrast to an individual solution.

Independent Variables

Actual expertise

In the high actual individual expertise condition, Participants *A* received a manual that contained information on electronic business (i.e., the *e-business training*) whereas in the moderate actual individual expertise condition, Participants A received a manual that contained information on New Media (i.e., the *New Media training*). Participants in the perceived individual expertise condition (i.e., Participants *B*) always received the New Media training. All participants had 90 minutes to read the manual and to memorize the given information. During this time, participants were allowed to take notes that were collected after training time. Completion time was adhered to for all participants. When participants stated that they were ready earlier, they were encouraged to re-read the manual for the remaining time.

High actual expertise (E-business training). The e-business training was an 89-page manual consisting of five chapters. In the first chapter, participants received some general information on the internet, for example information on the history and the functioning of the internet. In the second chapter, they were provided with information on e-business, i.e., they were given a definition of e-business, information on different kinds of e-business, and information on how one gets access to e-business. In the third chapter, participants were instructed how to get started in the internet and they were familiarized with some technical terms (e.g., “internet domain”). The fourth chapter included some information on the overall design of a website and the basic elements of an online-shop. Finally, the fifth chapter provided details about the selling process in the internet and security issues in the context of e-business.

Moderate actual expertise (New Media training). The New Media training was a 77-page manual also consisting of five chapters. In the first chapter, participants received some general information on New Media, i.e., a definition and examples of New Media (e.g., a computer disk). The second chapter contained information on the history of the internet. In the third chapter, participants were provided with information on the functioning of the internet and learnt some principles, for example the client-server-principle. Next, in the fourth chapter, they got information on internet services such as e.g., electronic mail. Finally, the fifth chapter included information on internet search, communication styles in the internet, and different internet user types.

The e-business training and the New Media training included some overlapping contents (e.g., information about the history of the internet), but only the e-business training contained helpful information in order to start an e-business.

Perceived expertise

Before manipulation of actual expertise, perceived expertise was manipulated. Note that only Participants *B* received this manipulation. At the beginning of the study, a basis for the manipulation was established by allegedly assessing knowledge about the internet. Five open-format questions about the internet (e.g., “What is the name of the client one needs in order to find CSO catalogues?”) were asked, and it was pretended that the results were evaluated during the experiment.

High perceived expertise. Participants in the high perceived expertise condition were told that the other team member was found to have *excellent* knowledge in the domain and that he or she will probably be very good at this type of task to be performed later. Participants in this condition were also informed that their own performance was average and that they did not do worse than the majority of students from non-technical subjects. This was done to prevent a decrease in self-efficacy. Participants were then given a text that was said to prepare them for later task completion and told that they should not mention that they had received this text but that they could use the information sought from the text.

Moderate perceived expertise. Participants in the moderate perceived expertise condition were told that the other team member was found to have moderate knowledge in the domain and that he or she would probably be average at this type of task. The other information was similar to that given to participants in the moderate perceived expertise condition.

The key information that the cooperation partner did excellently or moderately at the internet test, was reiterated before the team task.

Measures

Manipulation check for actual individual expertise. After the training, an internet knowledge test was conducted. A 10-item questionnaire was developed to measure actual expertise. The questionnaire included five items referring to e-business and five items referring to New Media. This was done to make sure that all participants had the same chance to answer an equal number of items, as it was not intended to influence self-efficacy with this questionnaire. However, for measurement of actual expertise only the e-business items were analyzed. The number of correct solutions was counted. A sample item was "What does 'Business-to-customer mean'?". One experienced rater who was blind to the conditions coded the knowledge test results. To obtain values for interrater reliability another rater who was also blind to the experimental conditions coded the knowledge tests results from 20 randomly chosen participants. Interrater correlations were r = .94 (p < .01) for the knowledge test on e-business, and r = .92 (p < .01) for the knowledge test on New Media.

Manipulation check for perceived expertise. To obtain performance evaluation scores for perceived individual expertise, we employed a composite measure of 6 bipolar adjectives (e.g. competent-incompetent) with a scale from Heilman, Rivero, and Brett (1991). We used a 9-point scale ranging from 1 (*absolutely disagree*) to 9 (*absolutely agree*). Perceived individual expertise was measured prior to task completion (Time 1), during task completion (Time 2), and after task completion (Time 3). Cronbach's alphas were .91, .92, and .95, respectively.

Team Performance. An experienced rater who was blind to the experimental conditions coded all hand-written e-business solutions for team performance. Concerning the dimensions, we followed a procedure from Sonnentag (1998). Dyads' solutions were rated along four criteria (completeness, detailedness, quality, and overall score) on a 5-point scale ranging from 1 (*very poor*) to 5 (*excellent*). Completeness comprised ratings of the number of categories that a dyad described. Detailedness encompassed the amount of information given on each of the categories. Quality included ratings on how elaborate the solution was. Finally, the overall score was a summary evaluation of the solution, different from an arithmetic mean of dimensions. For reliability analysis, a second rater also blind to the conditions coded 20 randomly chosen solutions. We computed intraclass correlations, using a two-way random model and consistency definition (Shrout & Fleiss, 1979). The values were .85 for detailedness, .89 for completeness, .91 for quality, and .80 for overall performance. According to the criteria specified by Cicchetti and Sparrow (1981) these values are "good" to "excellent". Hence, we used the scores of the first, i.e. more experienced judge in our analyses.

Cognitive ability. To make sure that effects are not solely attributable to an individual's general ability to learn and process information, we assessed cognitive ability with the Raven Advanced Progressive Matrices Test (APM; Raven, Court, & Raven, 1985). Specifically, the 12-item short version by Arthur and Day (1994) was employed. A mean score per dyad was computed.

Results

Manipulation checks

Manipulation check for actual individual expertise. An independent samples t-test was conducted to compare the internet knowledge scores for Participants A with the e-business training (actual expertise) and Participants A with the New Media training (no actual expertise). As expected, participants with actual expertise reported more correct answers on e-business items (M = 3.48, SD = 1.22) than participants without actual expertise (M = 0.34, SD = 0.56), $t(98) = -16.60$, $p < .0001$. Additionally, it was found that Participants A with the New Media training reported more correct answers on New Media items (M = 2.10, SD = 1.20) compared to Participants B without the New Media training (M = 0.10, SD = 0.30), $t(98) = 11.43$, $p < .0001$. In sum, results show that the actual expertise manipulation was successful. As participants in the new media condition scored substantially higher on the new media items than the participants in the e-business condition, it is unlikely that participants' self-efficacy in the new media condition was reduced by the administration of the knowledge test.

Manipulation check for perceived individual expertise. We conducted one-tailed independent samples t-tests to compare the performance evaluation scores of Participants B who had received information on Participant A as excellent performer (high perceived individual expertise condition) with the performance evaluation scores of Participants B who had received information on Participant A as moderate performer (moderate perceived individual expertise condition). At Time 1 (prior to task completion), analysis revealed that participants who had received the high perceived individual expertise manipulation gave higher performance evaluation scores (M = 6.63, SD = 1.00) compared to participants who had received the moderate individual expertise manipulation (M = 5.81, SD = .87), $t(98) = -4.34$, $p < .0001$. At Time 2 (during task completion), participants who had received the high perceived individual expertise manipulation also gave higher performance evaluation scores (M = 6.70, SD = 1.10 and M = 6.26; SD = 1.17), $t(98) = -1.92$, $p < .05$. The same was true for Time 3 (after task completion) with higher performance evaluation scores for participants with high perceived individual expertise (M = 6.81, SD = 1.17) compared to participants with moderate perceived individual expertise (M = 6.48, SD = 1.31), $t(98) = -1.34$; $p < .10$, yet only being marginally significant. In sum, results of the manipulation check for perceived expertise show that at Time 1 (prior to task completion) and Time 2 (during task completion) the manipulation of perceived expertise was successful and significant at the conventional levels ($p < .01$ and $p < .05$, respectively), and at Time 3 (after task completion) was marginally significant ($p < .10$).

Test of Hypotheses

We tested our hypotheses on the dyadic level. We ran a MANOVA with a 2 (actual expertise: moderate vs. high) x 2 (perceived expertise: moderate vs. high) design. As dependent variables the following dimensions were used: completeness, detailedness, quality, and overall evaluation. Table 8 gives means and standard deviations for team performance and Table 9 summarizes the results of the MANOVA. The results indicated a significant main effect for actual individual expertise on team performance, $F(4,93) = 10.44$, $p < .0001$, $\eta^2 = .31$. When the results for the dependent variables were considered separately in ANOVAs, significant differences with respect to the dependent variables *completeness*, $F(1,96) = 36.49$; $p < .0001$, $\eta^2 = .28$, *quality* $F(1,96) = 14.40$; $p < .0001$, $\eta^2 = .19$, and *overall score* $F(1,96) = 10.89$; $p < .0001$, $\eta^2 = .17$ were found. Inspection of the mean scores indicated that dyads with a member high on actual expertise outperformed those dyads with no member high on actual expertise in completeness (*M* = 2.98, *SD* = 0.92 and *M* = 1.94, *SD* = 0.79, respectively), quality (*M* = 3.08, *SD* = 0.88 and *M* = 2.32, *SD* = 0.68, respectively), and overall score (*M* = 3.06, *SD* = 0.76 and *M* = 2.40, *SD* = 0.70, respectively). There was no significant difference for dyads with actual expertise compared to dyads without actual expertise with regard to detailedness (*M* = 3.24, *SD* = 0.79 and *M* = 3.08, *SD* = 0.76, respectively). The effect sizes for the impact of actual performance on team performance were large (Cohen, 1994) with Cohen's *d* of 1.21 for the dimension completeness, Cohen's *d* of 0.97 for the dimension quality, and a Cohen's *d* of 0.90 for the overall score. Except from detailedness, actual expertise had an impact on all dimensions of team performance. In sum, these findings largely support Hypothesis 1.

There was no main effect for perceived individual expertise on team performance, $F(4,93) = 0.32$; *n.s.*, $\eta^2 = .013$. Inspection of the ANOVAs also did not reveal any differences for specific dependent variables. Thus, Hypothesis 2 was not confirmed.

Finally, results did not provide support for an interaction effect of actual individual expertise and perceived individual expertise, $F(4,93) = 0.91$; *n.s.*, $\eta^2 = .04$. Therefore, Hypothesis 3 was not supported.

Table 8. *Means and standard deviations for team performance*

	Actual expertise moderate				Actual expertise High			
Dependent variables	Perceived expertise moderate		Perceived expertise high		Perceived expertise moderate		Perceived expertise High	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Completeness	2.00	0.91	1.88	0.66	3.08	0.86	2.88	0.97
Quality	2.28	0.79	2.36	0.57	3.16	0.75	3.00	1.00
Detailedness	3.00	1.04	3.16	0.47	3.40	0.76	3.08	0.81
Overall score	2.32	0.80	2.48	0.59	3.20	0.65	2.92	0.86

Note. *N* = 100 dyads.

Table 9. Summary of Multivariate Analyses of Variances.

		Completeness		Quality		Detailedness		Overall score	
Factor	df	F	η^2	F	η^2	F	η^2	F	η^2
Actual expertise	(1,96)	36.49***	.28	14.40***	.19	0.64	.01	10.89***	.17
Perceived expertise	(1,96)	0.64	.01	0.40	.00	0.16	.00	0.09	.00
Perceived expertise x Actual expertise	(1,96)	0.05	.00	0.57	.01	2.26	.02	2.26	.02

Note. η^2 = *eta squared* ; *** $p < .0001$.

Additional Analyses

We conducted a supplementary analysis to control for alternative explanation of the results. One well-established finding in applied psychology is the relationship between cognitive ability representing individual differences with respect to individuals' capacity to process information and learn (Hunter & Hunter, 1984; Kanfer & Ackerman, 1989) and job performance across a variety of occupations (e.g. Schmidt & Hunter, 1998; Ree & Earles, 1991, Salgado et al., 2003). Cognitive ability was also found to be positively related to team performance (Devine & Philips, 2000; LePine, 2003; LePine, Hollenbeck, Ilgen, & Hedlund, 1997; Stewart, 2006). To show that actual expertise is more than cognitive ability, we tested if actual expertise impacts team performance beyond cognitive ability. To test for this, we ran hierarchical regression analyses. In Step 1 we entered the mean score per dyad in cognitive ability and in Step 2 we entered actual individual expertise and perceived individual expertise. We found that actual expertise explained variance in team performance beyond cognitive ability (β = .53, $p < .001$, $\Delta R^2 = .28$ for completeness; $\beta = .44$, $p < .001$, $\Delta R^2 = .18$ for quality, and β = .42, $p < .001$, $\Delta R^2 = .16$ for overall score).

Discussion

Although it is widely recognized that teams are important, surprisingly little is known about how individual expertise is related to team performance. In this study, we tested how the input factors actual individual expertise, perceived individual expertise, and a combination of actual and perceived expertise impact team performance. The findings of this experimental study provide evidence for a positive effect of actual individual expertise on team performance. That is, teams with a member high in actual expertise outperformed teams without a participant high in actual expertise. Except for detailedness, actual expertise had an impact on all dimensions of team performance. The finding that teams high in actual expertise do not necessarily produce a more detailed solution is not surprising. The knowledge of how to accomplish a task does not ultimately converge with giving extensive information.

In contrast to our expectations, perceived expertise had no effect on team performance. There are several reasons that might explain why perceived expertise did not affect team performance in this study. First of all, the task of this study was rather complex and required specific knowledge. Thus, it might not have been easily possible to solve this task when only being perceived as an expert. The study should therefore be replicated with a task that requires less specific knowledge. Secondly, perceived expertise might even be detrimental when not possessing actual expertise. A team that erroneously relies on someone who is described as an expert possibly shows worse team performance compared to teams with no information due to misdirection and reliance on the non-expert. Third, results of the manipulation check reveal that the effect of perceived expertise faded out during the course of the experiment. More specifically, participants in the high perceived expertise condition who were told that the other team member is excellent rated their partner's performance significantly higher than participants in the moderate perceived expertise condition who were told that the other person is moderate. This effect also holds during task completion, albeit it became weaker. Finally, after the team task, participants in the high perceived condition still rated their partner's performance higher compared to participants in the moderate perceived condition but there was only a small difference between the two conditions. These findings show that the manipulation of perceived expertise was successful but that working on the team task weakened the effect of the manipulation. There is research that has shown that task situations in which higher status individuals (i.e., perceived experts) interact with lower status individuals who also possess relevant task knowledge (i.e., other team members) can lead to less inequality of interaction (Cohen, Lotan, & Catanzarite, 1988). Thus, the perceived expert might have lost some of his or her authority to the cooperation partner which might be a reason why there was no effect of perceived expertise on team performance. Future research should illuminate the process of team interaction in order to investigate if perceived expertise is related to the team processes (e.g., more influence, participation) and how team processes result in higher team performance. It is possible that up to a certain point of interaction the perceived expert yielded influence. Finally, the laboratory setting restricted the amount of time the teams worked together on the team task and therefore might have limited the possibility that perceived expertise leads to competence improvement over time that in turn enhances team performance.

Furthermore, there was no support for the assumption that actual individual expertise and perceived individual expertise interact in a way that best team performance is achieved when both actual and perceived expertise is high. The effect of actual expertise on team performance was large and there was no asset of perceived expertise. One possible explanation might be that in this research setting using dyads it was easy to recognize the actual expert. Therefore, additional information on perceived expertise was not required. It is possible that in larger teams with more complex knowledge distribution requirements and more possibilities to exchange either shared or unshared information explicit cues on the team members' expertise might be more useful. Future studies should therefore examine if there is an interaction effect of actual and perceived expertise using larger teams.

In sum, parts of the study's findings were in contrast to what was a priori expected. Research suggested that there would be a positive relationship between perceived expertise and team performance as well as an interaction effect of actual and perceived expertise with regard to team performance. However, this study shows that only actual expertise impacts team performance when tested simultaneously with perceived expertise.

Strengths and Limitations

There are some strengths and limitations that will be discussed in more detail. First of all, the assets of this study will be considered. One of the strengths of this study is that actual and perceived individual expertise was manipulated experimentally so that the distinct and combined effects could be tested in a controlled setting. Furthermore, the experimental design of this study allows for causal inferences. Additionally, the task used in this study made it possible to create an adequate solution within the restricted time frame of this experiment. Another strength of this study was that the performance measure was objective and rated by two different raters who were unaware of the condition. Finally, team performance was split into different dimensions providing a better understanding of which aspects of team performance are affected by individual expertise.

There are also some limitations that should be considered when interpreting the results of the present study. First, the use of student teams and dyads might limit the generalizability of the findings. Because students have limited work experience, their behavior in teams might not represent that of individuals in actual work teams. One might also question if the processes that occur in dyads resemble those of larger teams. The reason for using dyads was that the research question should be tested in the most controlled manner possible. Research has shown that processes in dyads and larger teams are quite similar (Tschan, 2002). Nevertheless, future research should investigate if the findings of this study can be replicated in larger teams.

A second possible limitation that applies to all laboratory research on teams relates to the relative short-term duration of the teams compared to long-term work teams. The rather short duration of the teams might have led to the fact that the perception of expertise had no influence on team performance. In this study, participants might have been affected by the knowledge that they will not work together in the future. Thus, the information on the other team member as being excellent might not have been processed as profoundly and possibly was less relevant than would have been the case in a real work setting. In real life work settings where the impression of a co-worker of being excellent has developed over months or even years, the influence of perceived individual expertise might have been more powerful. The perceived expert might acquire knowledge and actual expertise due to the enhanced expectations. Future studies should examine the influence of perceived expertise on team performance in real life work settings where expertise has developed over a longer time frame.

Third, the study does not picture the complete input-process-output model (Hackman & Morris, 1975; Ilgen et al., 2005; McGrath, 1984). It might have been better to examine the team process in more detail. For example, perceived individual expertise could have had an impact on team processes but these effects did not translate into increased team performance. The rationale of the expectations state theory (Berger, Conner, & Fisek, 1974; Berger et al., 1977; Webster & Foschi, 1988) is that certain status characteristics (e.g., expertise) lead to performance expectations that in turn lead to changes in behavior, such as a perceived expert's increased involvement in the team process. However, it was not analyzed if perceived experts' changes in behavior also translate into better team performance or if they only result in a more active role as a team member and higher self-evaluations. Future studies should address which team processes occur during task completion and under which conditions these processes translate into better team performance.

Finally, one might question if the 90-minute training was adequate to establish actual expertise. The kind of expertise that was shown in this study is most certainly different from expertise that develops in applied work settings over months or even years by practice in a certain domain. However, we are confident that the goal of the manipulation to create actual expertise that potentially affects team performance was well attained. Furthermore, it was important to differentiate actual expertise from perceived expertise. As it is not possible to *experimentally* manipulate actual and perceived expertise over months or years in real work settings, the approach which was employed in this study seems to be an acceptable compromise. Additionally, for ethical reasons it is not possible to keep individuals from relevant knowledge in a certain domain in real work settings.

Implications for Theory and Practice

Results provide important practical implications when dealing with expertise in teams. The first practical implication concerns the question of how to staff teams. To trace which factors are responsible for team performance is especially exciting, because if composition factors are better understood, one can draw useful conclusions about how to compose the ideal team (Moreland, Levine, & Wingert, 1996). As to our knowledge previous studies have not experimentally established both actual and perceived expertise, the results from this study are very useful, as they show that especially actual expertise should be considered. Building on the results of this study, we recommend composing teams in a way that at least one high-performing team member is part of the team in order to achieve high team performance.

The second practical implication refers to personnel selection procedures. Decision-makers should pay special attention to select candidates with the appropriate domain-specific knowledge. Given that performance might have changed since the entry to the organization, managers should do repeated performance appraisals to assess employees' current expertise. This may also help to detect knowledge deficits. If the results show that there are in fact knowledge deficits, managers should update their employees' actual expertise by offering appropriate training programs.

Conclusion

Taken together, the present study contributes to our understanding of how individual characteristics are related to team performance. The study provides support for the importance of actual individual expertise with respect to team performance. This study disentangled the distinct and combined effects of actual and perceived expertise and showed that when simultaneously tested only actual expertise had an impact on team performance. Thus, for staffing teams, decision makers should focus on having team members with the appropriate knowledge and problem-solving competencies in a team.

Chapter 4: Expertise in Teams: A Longitudinal Field Study in Professional Software Design

Summary

The relationship between individual contributions and team performance was investigated in a longitudinal field study with 96 professional software engineers from 20 teams. We expected high performers to have a positive impact on project team performance. High performance was conceptualized in a twofold way: On the one hand we focused on team members who excel with respect to task functions in the team and on the other hand we focused on team members who excel with respect to team functions in the team. Results show that team performance is predicted by the best team member in task functions. Beyond that team performance benefits from team members who guide and initiate the task process, thus from the best team members in team functions. The study findings imply that teams profit from both team members high in task functions and team functions.

Expertise in Teams

Today's work life is increasingly characterized by the implementation of team work concepts (Ilgen et al., 2005; Sundstrom, McIntyre, Halfhill, & Richards, 2000; West, Tjosvold, & Smith, 2003). Especially, knowledge-intense and complex work, such as software design, often takes place in teams (Hoegl & Parboteeah, 2006; Jones, 1996). One of the advantages of teams is that they can integrate information in ways that an individual cannot. Work teams are social entities that interact at varying degrees of interdependency to attain specified, shared, and valued objectives (Salas et al., 1992).

It becomes more and more important that we understand the factors that determine high performance at the team level. One of the most important resources of a team is the expertise, or specialized knowledge and competence, of the individual team members (Faraj & Sproull, 2000; Hackman, 1987; McGrath, 1984). Yet, the possession of expertise at the individual level does not guarantee high levels of team performance (Klein & Kozlowski, 2000). Knowledge about whether and how individual characteristics (i.e., team member inputs) combine into high performance for the team as a whole is crucial in order to manage teams and still needs further investigation.

The dominant way of thinking about team member inputs and their relationship to team performance is to aggregate individual team members' characteristics. Several studies provided evidence that the mean level of team member inputs predicts team performance (Barrick et al., 1998; Kozlowski & Bell, 2003; Stewart, 2006). However, in knowledge-intense and complex work environments such as software design, the best team member is assumed to have an inordinate effect on team performance. Accordingly, results from laboratory studies indicate that the best team member has an impact on team performance (Baumann & Bonner, 2004; Bonner et al., 2002; Henry, 1995).

Furthermore, we assume that member inputs can be differentiated into two categories: Task functions and team functions (Bales, 1950; Bales & Slater, 1955; Marks & Panzer, 2004; McGrath, 1984). At a general level, task functions refer to behavior that aids in the completion of work-related activities, while team functions facilitate the interpersonal interaction necessary to work as a member of the team. Task functions imply that someone gives suggestions, opinions, and information on a certain topic and team functions comprise showing solidarity, understanding, and compliance (Bales, 1950). A team member who is excellent in task functions is assumed to be superior with respect to task performance. This implies that someone is proficient in problem solving, knows how to tackle difficult technical problems, and shows consistent superior performance in a certain domain. Similarly, a team member who is excellent in team functions is expected to be especially competent in empowering, motivating, and encouraging other team members. This can be done, for example, by being optimistic, creating a positive climate in the team and showing consistency in deciding. Team functions encompass certain processes that are used to coordinate, align, and monitor task work (Marks, Mathieu, & Zaccaro, 2001). This two-factor structure comprising task functions and team functions has been shown to represent higher-order factors for other more complex role categorizations and has been empirically supported (Blumberg, 2001; Forsyth, 1990; Hare, 1974). Thus, we adopt the distinction of task and team functions in this study.

This study uses a longitudinal field design to examine if team member inputs are related to team performance. The focus is on the *best* team member. The goal of the present research is to investigate if the best team member in task functions has a positive effect on team performance that goes beyond the average team level in task functions. Additionally, team members who are superior in team functions are expected to account for additional variance in team performance beyond the effect of the best team member in task functions.

In sum, the present study extends previous research on the relationship between team member inputs and team performance by analyzing the impact of the best member in a team with respect to task functions and the additional contribution of team members high in team functions.

Professional software design

Software design encompasses different tasks, such as requirement analysis, software design, programming, testing, and debugging (Sonnentag et al., in press). Many software design problems require working on complex and knowledge-intense tasks that do not have one single correct solution (Curtis et al., 1988; Hoegl & Gemuenden, 2001; Sonnentag, 2001). In this study, project teams in professional software design are examined. These teams work on defined, specialized, and time-limited projects and often disband after they have finished a project (Sundstrom et al., 2000).

Task functions and team performance

Team members who show superior performance and exceptional performance at the individual level are expected to show high performance in task functions at the team level. They will show good performance on the tasks and sub-tasks assigned to the team. One can expect that these team members who are high in task functions will positively influence team performance (Hackman, 1987).

Bottger and Yetton (1987) have shown that increasing team member competencies by knowledge training increases team performance. Bonner et al. (2002) found that experts positively influenced team decision making and team performance. Baumann and Bonner (2004) demonstrated in an experimental study that reliance on the best member was positively related to team performance. Team members high in task functions are expected to mention more relevant information during team work (Franz & Larson, 2002) as they are better able to identify task-relevant information (Shanteau, 1992). In sum, we assume that the performance score of the best team member in task functions will be positively related to team performance.

Hypothesis 1: The performance score of the best team member in task functions will be positively related to team performance beyond the average level of task functions in the team.

Team functions and team performance

Notwithstanding the importance of the team member with the highest score in task function, we assume that team functions that guide the team process are also necessary for a team to be productive. There is evidence that since the mid-eighties teams are given more responsibilities and authority for many aspects of work, such as for example planning, scheduling, assigning tasks to team members, and making decisions (Guzzo & Dickson, 1996).

Leadership

The process by which someone exerts influence over other people to guide, structure, and facilitate activities and relationships in a team or organization is usually referred to as leadership (Yukl, 2001). There exist a large number of different definitions of leadership (cf. Yukl, 2001) with different views about who exerts influence, and the outcome of the influence attempt. We believe that the influence process occurs within a social system (i.e., the team) and is diffused among the team members. Various leadership functions can be carried out by different people who influence what the team does, how it is done, and the way people interact with each other. As hierarchies become less dominant in today's workforce, functions that are normally assigned to formal leaders, are now often being fulfilled by other team members (Bono & Anderson, 2005; Marks et al., 2001; Marks & Panzer, 2004; Neubert & Taggar, 2004). Thus, team functions are often taken over by team members without a formal leadership role. Team members who are high on team functions are influential with respect to team coordination and impact how teams perform (Neubert, 1999). These persons are shown to impact team performance even in situations where there is a designated supervisor or formal leader (Wheelan & Johnston, 1996).

One of the currently most influential leadership theories distinguishes between transactional and transformational leadership (Bass, 1985; Burns, 1978; House, 1977). Transactional leadership builds on exchange of rewards for compliance. It is based on a mutual agreement between the person who exerts leadership and others and requires a certain amount of authority. Transformational leadership refers to the empowerment of other people by communicating ideas with optimism and enthusiasm (Bono & Anderson, 2005). The transformational leader motivates others to achieve higher performance, to attain more than they thought possible and to go beyond egoistic interests by addressing others' values and moral standards (Avolio, Bass, & Jung, 1999). In this study, we focus on transformational leadership because this form of leadership also is expected to be carried out by team members without a formal leadership role, according to the specific requirements of the task at hand (Tschan et al., in press; Zaccaro, 2001).

Two dimensions of transformational leadership are considered as team functions in this study: *Intellectual stimulation* and *idealized influence*. The first dimension, intellectual stimulation, is defined as a way of encouraging team members to be creative by questioning assumptions, reframing problems, and approaching old situations in new ways. New ideas and creative solutions are thereby elicited from other team members (Bass, 1985). The second dimension, idealized influence means that one has the capability to exert influence by serving as a role model and showing high moral standards. Persons who have high scores in idealized influence are respected and others try to emulate them.

Team members high in intellectual stimulation encourage team members to think about problems more thoroughly and to address problems (Keller, 2006). As the status quo is questioned and more intensive problem solving is fostered, the score of the best team member in intellectual stimulation will positively predict team performance beyond the best team member in task functions. In sum, we assume that the score of the best team member in intellectual stimulation can account for additional variance in team performance beyond the performance level of the best member in task functions within a team.

> *Hypothesis 2a*: The degree of intellectual stimulation shown by the team member highest on intellectual stimulation positively predicts team performance beyond the score of the best team member in task function.

Team members high in idealized influence have the capability to exert influence by serving as a role model and showing high moral standards (Bass, 1985). These team members are found to enhance commitment and internal motivation of the team members towards the team task (Bono & Judge, 2003; Scandura & Williams, 2004). Furthermore, teams with team members high in idealized influence believe that they perform effectively (Lowe, Kroeck, & Sivasubramaniam, 1996). Therefore, we assume that the score of the best team member in idealized influence can account for additional variance in team performance beyond the performance level of the best member in task functions within a team.

> *Hypothesis 2b:* The degree of idealized influence shown by the team member highest in idealized influence positively predicts team performance beyond the score of the best team member in task functions.

It can be expected that the scores in intellectual stimulation and idealized influence of the formal leader also predicts team performance beyond the score of the best team member in task functions. This study also explored the role of the formal team leader but the focus is on the best team member.

Task type

The operationalization of member inputs also largely depends on the task type a team has to solve (Barrick et al., 1998; Stewart & Barrick, 2000). Steiner (1972) offered a taxonomy that classifies tasks as additive, conjunctive, and disjunctive. Additive tasks require the equal input from all team members meaning that the team inputs are aggregated. Conjunctive tasks require each team member to perform at a minimum level in order to arrive at an acceptable team outcome. Finally, disjunctive tasks require only one team member to perform well in order for the team to be successful. As we are interested in examining how individual performance is related to team performance, we have to consider task type as a possible explanation for possible effects of the best team members on team performance. According to Steiner (1972), the best team members should be especially important when working on exclusive disjunctive tasks. It is assumed that it is important to consider task type but that in real work software design teams there is a mix of these three task types (Stewart & Barrick, 2000). Thus, task type is considered but is not expected to play a predominant role in the setting of this study.

Method

Overview

To test our hypotheses and to allow for causal inferences we used a longitudinal study design. The first round of data collection was performed after the companies agreed to participate (Time 1). Approximately 12 months later, the second round of data collection was performed (Time 2). We assessed data from team members (i.e., evaluations of their supervisors' leadership behavior), their co-workers (i.e., co-worker ratings of leadership behavior), their supervisors (i.e., supervisory ratings of individual performance), and managing directors (i.e., ratings of team performance).

Procedure

Basically, we followed two acquisition strategies. The first strategy was to directly contact companies by telephone or e-mail and asking for participation in the research project. The other strategy was to place advertisements in appropriate newspapers and professional journals. When the companies were interested in participation they were provided with detailed written information about the study. Next, we presented study details and policies personally at face-to-face meetings held in the companies. As the study was part of a larger research project, the companies had several requirements to meet. First of all, there had to be at least 3 members in a team. Second, teams had to conduct team meetings on a regular basis, i.e., at least once a month. Third, they had to work together at least for another 12 months. Finally, teams had to accept videotaping of two team meetings. Participation in the study was voluntary. As an incentive, companies were offered feedback after Time 1 and Time 2. These feedback sessions were conducted by members of the research team and covered general team work topics which did not interfere with our research question. After the companies gave consent for participation, the first round of data collection was performed.

Sample

A total of 29 software development teams from 28 different organizations in Germany took part in the overall research project. At Time 1, a total of 224 self-report questionnaires were sent to a total of 29 teams. Of these questionnaires, 205 usable questionnaires from 29 teams were returned (response rate = 91.5%). At Time 2, 129 participants from 22 teams returned their questionnaires (62.93 % of the 205 persons who participated at Time 1). Two teams did not participate at Time 2 because they did not do business anymore and five teams were not able to participate due to time considerations. Furthermore, for the purpose of this study two teams had to be excluded from analyses because less than 30 % of the team members provided data on relevant variables. The following numbers refer to the remaining 20 teams included in this study. At Time 1, we sent out a total of 1003 questionnaires to the team members, their co-workers, their supervisors, and managing directors. Of these questionnaires distributed, 850 were returned (response rate = 85 %). At Time 2, we sent out 1002 questionnaires from which 812 were sent back (response rate = 81 %). As we were interested in the *change* within a team from Time 1 to Time 2, we included only participants who participated at both data collection points. Finally, at Time 1 we had supervisor ratings for 96 participants, peer ratings for 101 participants, subordinate ratings for 19 supervisors, and manager ratings for each of the 20 teams. The final sample included 96 individual software engineers working in 20 teams.

The majority of participants were male (82.8 %). Mean age was 34.91 years (SD = 7.96). On average, participants had 8.47 years of professional experience (SD = 7.39) and had worked with 3.62 different programming languages (SD = 2.50) and 0.96 different design languages (SD = 1.16). Team duration was on average 3.70 years (SD = 2.56) and mean team size was 6.57 members (SD = 3.47). The software companies developed a variety of different software products (e.g., information and communication systems, systems for administrative and logistic purposes).

To make sure that there were no important differences between participants who returned questionnaires at Time 1 and Time 2 and participants who did not participate at Time

2, we conducted ANOVAs for the main study variables. We did not find any differences with respect to supervisors' performance ratings of team members at Time 1, neither for supervisory ratings ($M = 6.32$ and $SD = 1.34$ for respondents vs. $M = 6.19$, $SD = 1.10$ for non-respondents), $F(1,156) = .242$, *n.s.*.

There were also no differences between respondents at Time 2 and non-respondents with respect to years of professional experience ($M = 8.16$ and $SD = 7.18$ vs. $M = 8.50$, $SD = 7.88$), $F(1,174) = .006$, *n.s.*, experience with programming languages ($M = 3.64$ and $SD = 2.51$ vs. $M = 3.22$ and $SD = 2.18$), $F(1,170) = .784$, *n.s.*, and age ($M = 34.50$ and $SD = 8.0$ vs. $M = 35.09$, $SD = 7.71$), $F(1, 172) = .204$, *n.s.*.

Peer ratings of leadership did not yield any differences for respondents and non-respondents with respect to the dimension intellectual stimulation ($M = 3.58$ and $SD = 0.47$ vs. $M = 3.66$ and $SD = 0.60$), $F(1,168) = 1.254$, *n.s.* and idealized influence ($M = 3.52$ and $SD = 0.49$ and $M = 3.53$ and $SD = 0.60$), $F(1,168) = .015$, *n.s.*.

The subordinate ratings of supervisor's leadership behavior showed that there was no difference between respondents and non-respondents with respect to the dimension intellectual stimulation ($M = 3.87$ and $SD = 0.41$ vs. $M = 3.64$ and $SD = 0.56$), $F(1,27) = 1.491$, *n.s.* and idealized influence ($M = 3.82$ and $SD = 0.43$ and $M = 3.41$ and $SD = 0.60$), $F(1,27) = 3.91$, *n.s.*.

Measures

Individual-level task-functions performance. Team members' individual performance concerning task functions was rated by their supervisors at Time 1. Specifically, team leaders assessed each team member's performance with respect to eight job performance aspects suggested by Schuler, Funke, Moser, and Donat (1995) on a 9-point scale ranging from 1 = *extremely below average* to 9 = *extremely above average*: Scientific and technical knowledge, innovation, problem solving, theoretical work, communication with colleagues, cooperation with supervisors, customer service, and technical service. Cronbach's alpha was .88. More specifically, we computed a score for the best member in a team and for the average performance level within the team, not including the best member.

Score of the best member in task-functions. For each team, we determined the team member with the highest supervisor rating in task functions at Time 1. Thus, 20 participants were identified as being the best member in their respective team. Cronbach's alpha was .78.

Average score in task-functions. We computed a mean score for the supervisor rating in task functions at Time 1 including all team members except the best member. This was done to obtain an average performance score in task function for the team. Cronbach's alpha was .86.

Individual level team-functions performance. To assess team functions in the team a German version of Bass' (1985) Multifactor Leadership Questionnaire (MLQ) developed by Felfe and Goihl (2002) was used. The MLQ includes several dimensions of transformational leadership. We were interested in the dimensions intellectual stimulation and idealized influence. Following the traditional approach, we firstly assessed leadership by subordinates' ratings of their supervisors. Each supervisor was rated by 1 to 7 subordinates (M = 4.30; SD = 1.40). Secondly, as we intended to examine the leadership compilation of each team, we also assessed leadership by peers' ratings of their colleagues. For each team member we received 1 to 9 questionnaires (M = 5.26; SD = 1.42).

Team functions - intellectual stimulation (team leader). The scale consisted of 4 items. A sample item was "Reexamines critical assumptions to question whether they are appropriate" (Cronbach's alpha = .79). Subordinates rated their supervisor's behavior on a 5-point response format ranging from 1 = *never* to 5 = *always*. To ensure that aggregation from the individual level to the team level was appropriate, we computed an Eta², ICC (1), and ICC (2) value. The Eta² was .33, $F(18,72) = 1.937$, $p < .05$, ICC (1) was .16 , and ICC (2) was .44. According to Bliese (2000), aggregation of data is justified.

Team functions - idealized influence (team leader). The scale consisted of 4 items. A sample item was "He or she makes me proud to work with him or her". (Cronbach's alpha = .84). The Eta² was .35, $F(18,68) = 1.878$, $p < .05$, ICC (1) was .06, and ICC (2) was .21. These ICC values are comparably low, but they are still in the range of what Bliese (2000) describes to be typically found in field settings. Thus, we will use the aggregated score.

Team functions - intellectual stimulation (team members). The scale consisted of 4 items. A sample item was "Reexamines critical assumptions to question whether they are appropriate" (Cronbach's alpha = .82). Team members rated their peers' behavior on a 5-

point response format ranging from 1 = *never* to 5 = *always*. The Eta² was .34, $F(100,426) = 2.195$, $p < .0001$, ICC (1) was .19 and ICC (2) was .54. Therefore, aggregation is justified.

Highest score in intellectual stimulation for team members. We determined the team member with the highest score in intellectual stimulation.

Team functions - idealized influence (team members). The scale consisted of 4 items. A sample item was "He or she makes me proud to work with him or her". (Cronbach's alpha = .83). The Eta² was .38, $F(100,426) = 2.566$, $p < .001$. ICC (1) was .23 and ICC (2) was .60.

Highest score in idealized influence for team members. Likewise, we determined the team member with the highest score in idealized influence.

Team performance. Team performance was measured at Time 1 and Time 2. As a result of literature research (Brodbeck, 2001; Keller, 2001) and discussion with managers from different companies, six criteria for team performance were identified. Specifically, company managers were asked to rate the respective team on technical quality, compliance with time schedule, compliance with cost schedule, number of innovations, coping with unexpected incidents, and quality of customer relations. Managers made ratings on a 5-point scale ranging from 1 = *below average* to 5 = *above average*. Cronbach's alpha was .82 (Time1) and .80 (Time 2), respectively.

Control variables

Meeting frequency. As the best member's effect on team performance might be influenced by the frequency of team meetings, we entered meeting frequency at Time 1 as a control variable in the analyses. We assessed team meeting frequency with one item by asking how often they had team meetings. Participants could choose between four answers from 1 = *daily* to 6 = *less than once a month*. Individual answers were aggregated to the team-level. The Eta² was .50, $F(19,122) = 6.529$, $p < .0001$. ICC (1) was .46 and ICC (2) was .84.

Task type. Furthermore, we conducted additional analyses in which we controlled for task type. Following Steiner (1972), we measured if the task was perceived as predominantly additive, disjunctive or conjunctive at Time 1. An example for additive task type was "The input of each team member is equally important", for disjunctive task type "For this task it is sufficient if one person knows what to do", and for conjunctive task type "Team performance suffers if only one team member's performance is low". We measured the disjunctive task type with 4 items and additive and conjunctive task type each with 5 items. Participants made ratings on a 5-point scale ranging from 1= *do not agree at all* to 5 = *do absolutely agree*. Cronbach's alpha was .75, .71 and .77, respectively.

Results

Means, standard deviations, and variable zero-order correlations of the main study variables are presented in Table 10.

Preliminary Analysis

First of all, it was analyzed which task type was predominantly present in teams. A repeated measurement ANOVA with task-type as repeated factor revealed that there was a significant effect for task type, $F(1,19) = 53.06$, $p < .0001$. Inspection of the means showed that teams gave the highest ratings for additive task type ($M = 3.61$; $SD = 0.41$), followed by conjunctive task type ($M = 3.05$; $SD = 0.35$), and disjunctive task type ($M = 2.21$; $SD = 0.34$). Paired post-hoc T-Tests revealed significant differences between additive and conjunctive task type, $t(19) = 5.42$, $p < .0001$, additive and disjunctive task type $t(19) = 9.30$, $p < .0001$, and conjunctive and disjunctive task type, $t(19) = 7.28$, $p < .0001$. In sum, the task was rated as most additive and least disjunctive.

Test of Hypotheses

To test our hypotheses, we ran hierarchical regression analyses. Hypothesis 1 predicted that the performance score of the best team member in task functions (Time 1) positively predicts team performance (Time 2). Thus, we regressed team performance (Time 2) on individual performance of the best team member (Time 1). More specifically, in Step 1, we entered team performance at Time 1 and the frequency of team meetings (Time 1) as control variables. We entered team performance at Time 1 as a control variable, as we were interested in the effect of the best member in a team on *changes* in team performance.

Table 10. *Means, Standard Deviations, and Zero-Order Correlations for the Main Study Variables*

	M	*SD*	1	2	3	4	5	6	7
1 Meeting frequency (Time 1)	3.31	0.76	-						
2 Best member in task functions (Time 1)	7.55	0.74	.04	*(.78)*					
3 Average team score in task functions (Time 1)	6.06	0.84	.25	.79**	*(.86)*				
4 Best member in team functions – intellectual stimulation (Time 1)	4.01	0.30	-.23	-.16	-.24	*(.83)*			
5 Best member in team functions – idealized influence (Time 1)	4.07	0.27	.26	.04	.14	.49*	*(.83)*		
6 Team performance (Time 1)	3.62	0.66	.26	.58**	.64**	-.09	.30	*(.82)*	
7 Team performance (Time 2)	3.52	0.59	.26	.70**	.60**	.19	.45*	.51*	*(.80)*

Note. $N = 20$ teams; $p < .05$. ** $p < .01$. Cronbach's alpha shown in parentheses.

Note that this is a fairly conservative test. In Step 2, we entered the average performance score of the team into the regression equation. Finally, in Step 3, we entered the performance score of the best member in the team. Table 11 displays the results. As predicted, the performance score of the best member positively predicted team performance at Time 2 (β = .68, $p < .05$). The performance score of the best team member in task functions accounted for 15 % of variance in team performance at Time 2, even after controlling for team performance at Time 1 and the team's average performance level in team functions. Thus, Hypothesis 1 was confirmed.

Table 11: *Hierarchical Multiple Regression Predicting Team Performance from the Score of the Best Member in Task Functions and the Average Score in Task Functions in the Team*

	Team performance (Time 2)		
Variables (Time 1)	Model 1	Model 2	Model 3
Team performance	.47*	.19	.10
Meeting frequency	.14	.10	.22
Average team score in task functions		.45	-.06
Score of the best member in task functions			.68*
R^2	.28	.39*	.55*
ΔR^2	.28	.12	.15*

Note. N = 20; * $p < .05$. ** $p < .01$

In Hypothesis 2a we predicted that the team member with the highest score in intellectual stimulation positively affects team performance at Time 2, beyond the prediction of the team member with the highest score in task functions as rated by the supervisor. To test this hypothesis, in Step 1 we entered team performance (Time 1) and the frequency of team meetings (Time 1) as control variables. Afterwards, in Step 2 we entered the task performance score of the best member in the team. In Step 3, we entered the score of the best member in intellectual stimulation (Table 12). Analyses revealed that the task performance score of the best member in the team (β = .64, $p < .01$) and the intellectual stimulation score of the member highest on intellectual stimulation positively predicted team performance at Time 2

(β =.39, $p < .05$). The task performance score of the best team member in intellectual stimulation accounted for 14 % of variance in team performance, even after controlling for team performance at Time 1 and the score of the best team member in task functions. Therefore, Hypothesis 2a was supported.

Table 12. *Hierarchical Regression Predicting Team Performance from the Score of the Best Member in Task Functions and the Score of the Best Member in Intellectual Stimulation*

	Team performance (Time 2)		
Variables (Time 1)	Model 1	Model 2	Model 3
Team performance	.47*	.08	.04
Meeting frequency	.14	.21	.31
Score of the best member in task functions		.64**	.72**
Score of the best member in team functions (Intellectual stimulation)			.39*
R^2	.28	.55**	.68**
ΔR^2	.28	.27**	.14*

Note. $N = 20$; * $p < .05$. ** $p < .01$

Likewise, in Hypothesis 2b we predicted that the team member with the highest score in idealized influence positively predicts team performance at Time 2 beyond the prediction of the team member with the highest score in task functions as rated by the supervisor. To test this hypothesis, in Step 1 we entered team performance (Time 1) and the frequency of team meetings (Time 1) as control variables. Afterwards, in Step 2 we entered the performance score of the best member in the team. In Step 3 we entered the score of the best member in idealized influence (Table 13). Analyses revealed that the score of the best member in the team (β = .64, $p < .01$) and the best member in idealized influence positively predicted team performance at Time 2 (β = .41, $p < .05$). The performance score of the best team member in idealized influence accounted for 14 % of variance in team performance even after controlling for team performance at Time 1 and the score of the best team member in task functions. Therefore, Hypothesis 2b was supported.

Table 13. *Hierarchical Regression Predicting Team Performance from the Score of the Best Member in Task Functions and the Score of the Best Member in Idealized Influence*

	Team performance (Time 2)		
Variables (Time 1)	Model 1	Model 2	Model 3
Team performance	.47*	.08	-.06
Meeting frequency	.14	.21	.14
Score of the best member in task functions		.64**	.71**
Score of the best member in team functions (Idealized influence)			.41*
R^2	.28	.55**	.69**
ΔR^2	.28	.27**	.14*

Note. $N = 20$; * $p < .05$. ** $p < .01$

Supplementary analyses

As one might be interested in the impact of team leaders' impact on team performance with respect to team functions we ran additional hierarchical regression analyses. In Step 1 we entered team performance (Time 1) and the frequency of team meetings (Time 1) as control variables. In Step 2 we entered the performance score of the best member in task functions in the team. In Step 3 we entered the score of the team leader in intellectual stimulation at Time 1. Results show that the score of the team leader in intellectual stimulation did not predict team performance at Time 2 (β =.25, p = .24). Likewise, we entered in a further regression analysis the control variables, and in Step 2 the score of the best team member in task function. In Step 3, we entered the score of the team leader in idealized influence at Time 1. Again, the score of the team leader in idealized influence did not significantly predict team performance at Time 2 (β = -.05, p = .83).

Discussion

The purpose of the present longitudinal field study was to examine how team members' inputs are related to team performance. Team members' inputs were differentiated in the two categories task functions and team functions (Bales, 1950; Bales & Slater, 1955). It was argued that the best team member in task functions helps to improve team performance beyond the average level of task functions within the team. Furthermore, it was assumed that the best members in team functions can explain additional variance in team performance after accounting for the best team member in task functions.

The findings of this study strongly support the hypotheses. Analyses showed that the performance score of the best team member in task functions positively predicted team performance beyond the average level of task functions within the team. Additionally, results of the study provide support for the assumption that team functions which are intellectual stimulation and idealized influence can explain additional variance in team performance beyond the best member in task functions.

The most remarkable finding is that the *best* member in task functions exerts a substantial contribution on team performance beyond the average level of task functions within the team. Previous research has mainly suggested that the average level of team members' inputs is crucial for effective teams (Devine & Philips, 2001; Halfhill et al., 2005; LePine, 2003). Our analyses show that the score of the best team member in task functions and the average score in task functions have high correlations. Thus, it cannot be ruled out that when using a larger sample the average score is also related to team performance. The asset of this study is to take the average score in team functions into account and to examine if the best team member in task functions can additionally predict team performance. Results yield strong evidence for this assumption. In software design teams, which have been examined in this study, the best team member in task functions is beneficial for team performance. Possibly, software design teams that work on complex and knowledge-intense work require a team member who knows when to do what and how to accomplish tasks.

Furthermore, with respect to team functions, the *best* team member in the respective team function could account for additional variance in team performance beyond the best team member in task function. These team functions might be interpreted as an additional layer of requirements compared to individual task completion that have to be met in team settings and coordinate the way of working together effectively with others (Cannon-Bowers, Tannenbaum, Salas, & Volpe, 1995; Cooke & Kiekel, 2001; Cooke et al., 2003). Team members need to coordinate their activities with others who are working towards the same goal. Results show that team members high in team functions contribute positively to team performance.

For disjunctive tasks where the input from one team member is sufficient to solve the task, the results would not be very astonishing (Steiner, 1972). In this case, one would expect that the best team member yields substantial influence on team performance. To rule out that the effect is simply attributable to task type it was examined which type of task teams were predominantly working on. Team members judged the task predominantly as an additive task. This makes the findings of this study even more noteworthy, as it is not simply explained by the type of task. In real work settings, it can mostly be assumed that a team rarely performs only one type of task (McGrath, 1984) but rather a mix of additive, conjunctive, and conjunctive task type (Stewart, 2005).

Surprisingly, in this study the scores of formal leaders in team functions did not seem to influence team performance. This finding is in contrast to previous research on transformational leadership that has shown a positive relationship between transformational leadership and team performance (Lowe et al., 1996). One possible explanation might be that most of the studies were cross-sectional and included self-reports only (Avolio et al., 1999). Another possible explanation can be due to the nature of software design teams. Team members work on complex and uncertain tasks that make it necessary to work interdependently to find solutions to novel tasks (Hoegl & Parboteeah, 2006). This offers the opportunity for all team members to participate in decision making and taking charge of team functions (Ford & Randolph, 1992).

Strengths and Limitations

There are some strengths and limitations that should be considered in more detail. One of the strengths of this study is that the design was longitudinal. This allowed a much stronger inference of causality and exclusion of alternative explanation compared to cross-sectional data (Taris, 2000). The time lag and the fact that it was controlled for the outcome variable at Time 1 allowed predicting *change* in team performance. The statistically significant results may be regarded as especially noteworthy, as the input factors as evaluated by the supervisors and co-workers relate to project team performance approximately 12 months later as evaluated by the managing director. The design of the study adds to research as it provides longitudinal empirical evidence that many previous studies asked for (e.g., Hoegl & Gemuenden, 2001; Stewart & Barrick, 2000).

Furthermore, data was gathered from multiple sources (i.e., team member ratings, co-worker ratings, supervisory ratings, and manager ratings) which protects from common method bias (Podsakoff et al., 2003). By using measures from different persons for assessing the variables, alternative explanations for the observed relationships due to systematic measurement error can be ruled out. Thereby it was impossible for the raters to influence observed relationships between the predictor and criterion variable, for example by implicit theories (Podsakoff et al., 2003). This is a remarkable strength of this study and makes the conclusions drawn from the study much more powerful.

Additionally, the study was conducted in real work teams and actual work settings providing a high degree of external validity. Moreover, a variety of companies was involved so that the results can be generalized to different organizational contexts.

There are also some limitations that have to be discussed before making implications. One limitation is that the teams included in this study were relatively small and all from the same industry type. This restricts generalizability of the findings by team size and industry. Hence, future research should replicate the findings of this study in other organizations, for other team sizes, and different tasks.

Additionally, one might criticize the way task functions and team functions were measured in this study. Task functions were assessed by supervisory ratings that comprised judgments of a variety of an employee’s competencies. This questionnaire asked, for example, for ratings of scientific and technical knowledge, innovation, problem solving, and theoretical work. At the same time, employee’s competencies in customer service, cooperation with supervisors, and communication were assessed. Team functions were measured by peer-ratings with two subscales of leadership. Although there might be better and more elaborate ways of measuring team functions it seems plausible that the scales for task functions and team functions measured different constructs. This assumption is supported by the fact that different people emerged to be the best team members in the respective functions. Nevertheless, future studies should use scales that make a very clear distinction between the two functions, namely task and team functions.

Another limitation of the study concerns the relatively small sample size. In general, this is a difficulty in research on teams (Barrick et al., 1998) and intensifies in a multi-source, longitudinal field study. Thus, the complexity and resource demanding data collection permits only a limited team-level sample. The small sample limits the options for data analysis and statistical power. Hence, while this study provides support for the hypotheses, this study does not provide the statistical power to dismiss relationships not supported by statistically significant results. However, the significant results are remarkable because they were found despite the small sample size. Nevertheless, the study should be replicated by using a larger sample size.

Implications for Theory and Practice

Results of the present study provide support for the crucial role of the best team member in task functions for team performance and the additional benefit of team members who are high in team functions. The study extends existing literature on team composition (e.g., Barrick et al., 1998; LePine et al., 1997; Stewart, 2006) by showing that the best team members predict team performance beyond the aggregated level of team members' competencies.

A crucial question for future research refers to the predictors of high scores in task functions (Ericsson et al., 1993; Hacker, 1992, 1998) as well as in team functions (Cooke et al., 2003). Additionally, it remains an open question if the different functions within a team are constant or if they can change over time. One should also examine if and how the competencies of the best members spill over to other team members.

Furthermore, future research might fruitfully address the question of having more than one team member high in task functions in the team. The present study focused on one best member in comparison to the other team members. It would be helpful, for example, for staffing issues to gain knowledge about the relationship of team members' inputs and team performance when teams possess more than one outstanding team member. One possibility would be that the inputs of more than one best member combine in a synergistic way, whereas another possibility would be that having more than one best team member in task functions evokes conflict and hassles that in turn lead to decreased team performance.

The team functions investigated in this study refer to two dimensions of transformational leadership (i.e., intellectual stimulation and idealized influence). Future research should take other possible team function variables into account, such as coordination and conflict (Hoegl & Parboteeah, 2006; Stewart & Barrick, 2000).

Finally, the role of formal leaders in software development teams needs further investigation. Perhaps, formal leaders in complex environments such as software development should implement a model of shared influence and authority of the project and act as facilitators rather than authorities (Manz & Sims, 1987).

This study has practical implications for selection purposes and training. The results clearly indicate that effective teams require task functions as well as team functions. Thus, for personnel selection one should take care to have teams with at least one team member who has excellent task function competencies. To further improve team performance, the team should also include team members high in team functions who support the team member high in task functions. For training purposes the results imply that technical knowledge is important and should be implemented by knowledge-focused training and assessed on a regular basis. Similarly, team functions should be trained, as there is evidence that leadership functions can be trained (Bass & Avolio, 1990; Seifert, Yukl, & McDonald, 2003; Towler, 2003). Managers should be careful to create a personnel pool where individuals are proficient in task functions as well as team functions.

Conclusion

The findings emphasize the importance of the best team member in task functions and suggest that team members high in team functions can help to additionally contribute to team performance. In sum, results of this study contribute to existing studies in team literature dealing with the relationship between individual characteristics of team members and team performance and extend previous research by focusing on the best team members.

Chapter 5: Integration and Conclusions

Introduction

In this final chapter the main findings are summarized; important assets as well as limitations of the research are discussed, theoretical and practical implications of the results of the dissertation are addressed, and recommendations for future research examining expertise in context are formulated.

Summary of the main findings

Organizations increasingly implement teamwork concepts (Guzzo & Dickson, 1996; Ilgen et al., 2005; Kozlowski & Bell, 2003) so that the topic of high team performance is gaining importance. As teams are composed of individuals, high individual performance and team performance are closely linked to each other. Knowledge about which aspects of individual performance are relevant for team performance and how individual performance translates into team performance is extremely useful for personnel selection and training (Klein & Kozlowski, 2000). Individuals who show superior and exceptional competence are referred to as high performers or experts (Ericsson & Smith, 1991). This conceptualization differs from defining experts by the amount of experience.

This dissertation examined the influence of high performers or experts on team performance, the processes underlying this effect, the distinct and combined influence of actual and perceived expertise on team performance, and the impact of expertise in task functions and team functions on team performance. These issues were addressed in three empirical studies that used different but complementary approaches.

Study 1 and 2 (Chapter 2 and 3) were laboratory studies whereas Study 3 (Chapter 4) was a longitudinal field study. These studies referred to the question if and how high individual performance is related to team performance. However, each of these studies focused on different aspects. Study 1 tested in a quasi-experimental approach how high individual performance is related to dyads' team performance. The conceptual framework for this study follows work from Hackman and Morris (1975) and McGrath (1984) who expressed teamwork in terms of inputs that lead to processes that in turn lead to outcomes (the input-process-output, or I-P-O-model). In this study it was argued that high individual performance (i.e., the input) is positively related to team performance (i.e., the output) and that planning behavior is the core underlying psychological process. To obtain a measure for individual performance, participants first worked individually on a task. Task solutions were rated by independent coders, and the best team member per dyad was determined based on the coders' ratings. To assess the process, a micro-analytical approach was employed: Participants worked in dyads on a team task and this interaction process was videotaped and transcribed. To assess team performance, the task solution of the conjoint task solution was rated by independent coders. Results showed that high individual performance was positively related to team performance. Furthermore, results revealed that local planning (i.e., thinking about and communicating the next step without extensively reflecting on it) but not planning ahead (i.e., reflecting and deciding about the future course of action) partially mediated the relationship between high individual performance and team performance. The findings of Study 1 emphasize the relevance of high performers in teams and underline the potential of local planning behavior as an important factor in promoting team performance.

In contrast to Study 1, the focus of the second study was to disentangle the effects of different types of expertise on team performance. Therefore, this study explicitly contrasted actual and perceived expertise. The research question was tested with an experimental study design with the experimental factor actual and perceived expertise. Actual expertise was manipulated by a task-relevant vs. non task-relevant training. Perceived expertise was manipulated by information on the performance of the cooperation partner. Participants worked together in dyads on a team task, whereby each dyad consisted of one team member manipulated in actual expertise and one team member manipulated in perceived expertise. Team task was assessed by ratings of the teams' task solutions. Results of this study provided support for the effect of actual expertise but not for perceived expertise or an interaction effect. Findings of Study 2 complement findings of Study 1 by providing evidence for the impact of actual expertise on team performance. Furthermore, Study 2 extends previous research by showing that when manipulated simultaneously only actual expertise had a positive impact on team performance and not perceived performance.

Finally, Study 3 was a longitudinal field study in professional software design and analyzed how different functions (i.e., task functions and team functions) are related to team performance. Study 3 was designed to extend the findings from Study 1 and 2 which have been conducted in the laboratory setting to the field setting. The basic line of argument was that the best team member in task functions positively predicts team performance. Furthermore, team members high in team functions were expected to be able to additionally contribute to team performance. Evaluations of task functions were obtained by supervisory ratings and evaluations of team functions were gathered by peer ratings. Team performance was rated by the companies' managing directors. Results showed that team performance was predicted by the best team member in task function. Additionally, analyses revealed that team performance benefits from team members who guide and initiate the task process, thus from the best team members in team functions.

Overall, the results of the three empirical studies provide consistent evidence across different research settings that the performance level of the best team member is positively related to team performance. The three studies of this dissertation extend previous research in several ways. All studies embedded expertise in the team setting. Study 1 expands knowledge about how individual performance is translated into team performance. In contrast to other studies from the team literature that also have studied mediators (e.g., potency, planning, and shared mental models) between individual characteristics and team performance (e.g., Argote & McGrath, 1993; Gully et al., 2002), this study uses a micro-analytical approach and clearly shows that the high performer is more involved in the process compared to the moderate performer in the dyad. Study 2 illuminates how different types of expertise affect team performance. Studies have analyzed if actual expertise has a positive impact on team performance (e.g., Bottger & Yetton, 1987), if perceived expertise affects team performance (Eden, 1990, 1993; McNatt, 2000) and if it is beneficial when actual expertise is recognized. The latter issue refers to the question if actual expertise is at the same time perceived as such by other team members (Baumann & Bonner, 2004; Henry, 1995). To my knowledge, Study 2 is the first that systematically combines the different types of expertise and tests for the effects in one single study. The contribution of Study 3 is primarily that expertise is studied in a longitudinal field study. This issue was rarely studied in earlier research (for exceptions see e.g., Lewis, 2003). Additionally, Study 3 provides support for the importance of the best team member beyond the average performance level in the team. Furthermore, in Study 3 expertise was differentiated in task and team functions. The positive impact of the best team member in task functions on team performance was improved by team members high in team functions.

Comparison between perceived expertise (Study 2) and evaluations of task functions (Study 3) might raise the question in how far the conceptualizations of expertise of these two studies overlap and if the results converge or differ from each other. Assuming that the evaluations of task functions in Study 3 represent perceived expertise would contradict results from Study 2. Most certainly, supervisory reports as used in the third study contain more than only evaluations of perceived expertise. In real work settings, it can be assumed that supervisors who monitor teams are well aware of their subordinates' actual task performance. They frequently observe if certain subtasks are accomplished and these do not always only refer to the team's performance but also to the individual team member's performance. Especially in software development teams it is provable if a software feature is functioning in the intended way (Jones, 1996). Although supervisory ratings are probably not completely unaffected by techniques such as impression management, it seems plausible to believe that they contain a large amount of actual task performance.

Strengths and limitations

In the next section, the assets and limitations of the studies of this dissertation are considered in more detail. First, the strengths of this dissertation will be discussed.

Strengths of this dissertation

Combination of laboratory and field studies

One of the noteworthy strengths of this dissertation is the combination of laboratory and field research. The first offers the advantages of a controlled research setting providing high internal validity, whereas the latter allows for testing the hypothesized relationships in a meaningful work setting with high external validity. A combination of laboratory and field settings provides a certain amount of both internal and external validity (Bortz & Döring, 2005). The consistency of the findings of this dissertation, in the laboratory as well as in the field setting, indicates the robustness of the phenomenon.

Causality

Another strength of this dissertation refers to causality. The fact that an experimental design (Study 2) and a longitudinal study (Study 3) were used allowed a much stronger inference of causality and exclusion of alternative explanation compared to cross-sectional data (Taris, 2000). In Study 3, the time lag and the fact that it was controlled for the outcome variable at Time 1 allowed predicting *change* in team performance. Of course, to make sure that there is no reverse causation, future research should test if team performance has effects on individual performance. Particularly Study 2 does present clear evidence for causal relationships between individual expertise and team performance.

Type of measurement

A further strength of this dissertation concerns the type of measurement that was used to assess the core study variables. In Study 1, the individual expertise and team performance was assessed objectively by raters. Additionally, observational data on the micro-analytical level was used to obtain data for the team process. In Study 2, individual expertise was instigated experimentally and team performance was, as in Study 1, measured by raters. The use of objective measures has several advantages compared to subjective measures like self-ratings, because bias effects such as for example social desirability are ruled out (Podsakoff et al., 2003). In Study 3, data on individual expertise and team performance was obtained by different sources (supervisory ratings, co-worker ratings, and manager ratings). Of course, objective measures are also not perfect, but one can conclude that common source variance was not a major problem (Podsakoff et al., 2003). In sum, the objective and multi-source data-collection method employed in the studies is a considerable strength of this dissertation.

Operationalization of Expertise

Furthermore, expertise was not restricted to only one narrow type of expertise, but it was operationalized in different ways. In Study 1, expertise was considered as high performance on a domain-specific task and assessed by objective task performance on a software design task. In Study 2, the expertise concept was broadened by distinguishing between actual and perceived expertise. Finally, in Study 3 expertise was conceptualized in a two-fold way: On the one hand as being the best team member in task functions and on the other hand as being the best team member in team functions. Evaluations were obtained by supervisors and co-workers. Thus, this dissertation tested the core aspect of expertise, namely superior task performance, and broadened it to other types of expertise to provide a better picture of the relationship of individual expertise and team performance.

Consideration of Multiple Levels in Organizations

Additionally, this research paid attention to an upcoming topic in Industrial and Organizational psychology that deals with multiple levels of analysis (Bryk & Raudenbush, 1992; Klein & Kozlowski, 2000; Kozlowski & Bell, 2002; Rousseau, 1985). Kozlowski and Klein (2000) regard the recognition of different levels in organizations as being fundamental to the levels perspective. They describe organizational processes as micro phenomena that are embedded in macro contexts. Furthermore, they state that organizational scholars often put an emphasis of the macro level focusing on aggregated or collective responses. Consequently, individual variation is mostly ignored. Similarly, often there is also an emphasis of the micro level focusing merely on individual differences and assuming that aggregation masks individual differences. Klein and Kozlowski (2000) consider both types of single-level perspective as not adequate for describing organizational behavior. By conceptualizing and assessing performance at the individual and at the team level, it was aimed at taking this organizational complexity into account and at giving theoretically rich and relevant implications. The underlying assumption of this dissertation is a bottom-up process assuming that team performance emerges as a result of individual team members' contributions (Klein & Kozlowski, 2000). This approach allows a more precise specification of the relationship between individual expertise and team performance.

Limitations of this dissertation

The Expertise Concept

Despite the fact that expertise was operationalized in different ways in this dissertation (cf. the section about the strengths of this dissertation), one might criticize the way of determining the expert in a team. Is it legitimate to refer to these team members as exceptional and outstanding performers (Ericsson & Smith, 1991)? The best team member or expert was always determined *relative* to the other team members. In Study 1, based on individual task completion, it was determined which team member was better compared to the other one. Thus, the difference in the performance level between the two team members could possibly be only small. Consequently, there were no equal differences between the two team members in different dyads. In Study 2, the actual expert received domain-specific knowledge regarding e-business that the other team member did not receive. However, the other team member also possessed some basic and everyday knowledge regarding this domain. Again, the actual expert was superior relative to the cooperation partner who did not receive specialized training. Finally, Study 3 also described experts as team members who relative to their co-workers were superior with respect to task and team functions. Yet, it was possible that the difference between the best team member and the second best team member was only small. In Study 1 and 3, the score of the best team member and the average performance level in the team were moderately correlated. This makes sense, as participants were computer science students (Study 1) and professional software engineers (Study 3) and had some experience in software design. Future research should address the question of how large the magnitude of difference between the best team member and the other team members has to be in order to yield an inordinate effect of the best team member on team performance.

Size of Teams

As a possible weakness of this dissertation, one might address the use of dyads in the two laboratory studies (Study 1 and Study 2). One might be concerned with the question if dyads' team processes resemble those of larger teams. Although past research has discussed some issues that seem to be different in dyads compared to larger teams (e.g., a restricted number of communication channels and possibly less elaborated team structures, Levine & Moreland, 1990), there is also evidence that processes in dyads resemble the processes of larger teams in many ways (Tschan, 2002). The advantage of using dyads in the laboratory studies (Study 1 and Study 2) was that one could analyze how individual expertise and team performance are interrelated in the most controlled manner possible. Furthermore, Study 3 of this dissertation overcame this weakness of using dyads by examining larger real-work teams. However, future research should also conduct the laboratory studies using larger teams in contrast to dyads.

Other Mediators

In Study 1 of this dissertation, planning behavior was examined as a mediator between individual expertise and team performance. Local planning behavior was shown to be a partial mediator. Of course, there might be several other potential mediators (Ilgen et al., 2005) which were not considered in the present research. For example, several studies in the past have shown that potency, defined as team members' collective belief that they can be effective (Guzzo et al., 1993), can explain why some teams work and others do not. Future research should take potential other mediators into account to better understand how individual expertise impacts team performance.

Task Type

The present research shows that the score of the best team member positively predicts team performance in various settings on a variety of tasks. Yet, most of the studies from this dissertation are software tasks (an exception is the e-business task used in Study 2). These tasks can be characterized as ill-structured and complex (Guindon, 1990). There is evidence that the ability of the team to learn from the best team member is greater when teams are working on complex tasks (Bonner et al., 2002). For these work teams it seems to be essential to have at least one outstanding individual who is capable of solving the task. Future studies should investigate if the results also hold when using different tasks of varying complexity.

Theoretical implications

The results from this dissertation suggest that teams clearly benefit from the *best* member in the team and support the notion that individual expertise can be used as a team composition variable that predicts team processes and team outcomes.

With respect to expertise research, this dissertation shows that high individual expertise is not restricted to positive outcomes at the individual level but also positively impacts outcomes at the team level. This finding supports earlier results from expertise research that have shown that experts are - contrary to opposite intuitive assumptions (Shanteau, 1988; Stein, 1995) - more involved in communication and cooperation processes (Curtis et al., 1988; Lipshitz & Ben Shaul, 1997), that they are perceived as socially competent and spend more time in meetings and consultations than moderate performers (Sonnentag, 2001; Turley & Biemann, 1995).

Researchers in Industrial and Organizational Psychology have repeatedly emphasized that organizational environments become increasingly complex, dynamic and uncertain (Ilgen & Pulakos, 1999). These changes in today's workforce ask for an improvement of measurement of multiple levels in organizations. A stronger consideration of the micro level (e.g., the individual level) and the macro level (e.g., team level) and the presumed link between these two levels is needed (Klein & Kozlowski, 2000). This dissertation addressed the question of if and how individual expertise impacts team performance accounting for the different levels in organizations. Much research has been conducted with regard to team composition as a precursor of team performance (e.g., Barrick et al., 1998; LePine et al., 1997; Stewart, 2006). The studies from the present research expand existing research by showing that the best team member is important beyond the average performance level of the team. Furthermore, the studies provide support for the assumption that individual expertise should be considered as a useful variable when addressing team composition. This extends previous research that has most often dealt with personality and cognitive ability as team composition variables (e.g., LePine, 2003; LePine et al., 1997; Stewart, 2006).

Practical implications

Results of the present studies provide support for the crucial role of the *best* team member (Study 1 and Study 2). Furthermore, support for the additional benefit of team members high in team functions (Study 3) was found.

For staffing teams these results imply that one should be careful to have at least one team member who possesses excellent task functions in a team. Furthermore, one should select team members who show high competencies with respect to team functions. Recently, Morgeson et al. (2005) tested if research on individual personnel selection transfers to cooperative selection situations. They conclude that the constructs shown to be predictive for individual performance appear to transfer to performance settings where employees are expected to work cooperatively.

For training purposes this dissertation implies that both task functions and team functions should be trained. Emerging models of team training suggest that one should create shared or compatible systems of knowledge at the team level in addition to specific training at the individual level (Kozlowski, Brown, Weissbein, Cannon-Bowers, & Salas, 2000). A special type of training, namely cross-training, could be used (Blickensderfer, Cannon-Bowers, & Salas, 1998; Cannon-Bowers et al., 1995; Marks, Sabella, Burke, & Zaccaro, 2002). In cross-training, team members are trained on the positions of other team members to the extent that they are trained on their own positions (Cooke et al., 2003). One of the advantages of this type of training is that team members can acquire and improve competencies that go beyond their domain of task responsibility. Furthermore, cross-training allows developing models of interaction between team members that facilitate coordination processes of the team. By using cross-training and improving team knowledge, a team's ability to assess the current situation can be improved (Cooke et al., 2003). This would be somehow similar to individual expertise (e.g., Chase & Simon, 1973; Chi et al., 1982) and a possibility to let the other team members learn from the expertise of the best team member.

Future Research

There are several issues that have not been considered in the present research and provide starting points for future research questions. Future research should examine if the positive impact of individual expertise on team performance is restricted to the fact that there is *one* outstanding individual in the task. It remains unclear, if more than one best member in a team with respect to task functions further improves team performance or if in that case team performance is rather hindered than promoted.

Additionally, there is a need to elaborate more precisely how knowledge from the best team member is distributed within the team. Is there a 'spill-over'-effect to the other team members in a way that they improve their performance by working together with an expert? Research on this issue is still relatively scarce. Lavery, Franz, Winquist, and Larson (1999) using a judgment task showed that there is a value of learning from the best team member and results from studies by Littlepage, Robison, and Reddington (1997) and Bonner et al. (2002) point in the direction that teams learn from the most knowledgeable team member. However, future research is needed to gather more information about factors that facilitate learning from the best team member.

Another interesting question would be if it is desirable that one best team member has high competencies in team functions as well as in task functions or if these processes should better be executed by different team members. According to Bales'

(1950) role theory, it would presumably be better to have different team members for different team functions. This question should be addressed in future research.

Future research should also consider dynamic conditions experienced by teams over time. This could account for today’s challenge to react to complex demands and constantly-changing work requirements (Ilgen & Pulakos, 1999; Sonnentag & Frese, 2002).

Final remarks

This dissertation examined if and how individual expertise and team performance are related to each other. To consider the best team member is highly relevant, because if composition factors are better understood, one can draw useful conclusions about how to compose well functioning teams. This dissertation provided clear and consistent evidence from the laboratory and field setting that the best team member plays a crucial role beyond the average performance level of the team.

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